2018 Guadalupe River Watershed Fisheries Monitoring

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Reports included:

Water Year 2018 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed

Guadalupe River 2018 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System

Water Year 2018

Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed



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Executive Summary

The Santa Clara Valley Water District (SCVWD) has been conducting juvenile steelhead (*Oncorhynchus mykiss, O. mykiss*) monitoring since 2004 as part of the downtown Guadalupe River Project. The monitoring was concluded in 2013, but SCVWD recommended the continuation and expansion of monitoring efforts to better understand *O. mykiss* numbers and distribution in the Guadalupe Watershed. In 2013 the Adaptive Management Team (AMT) approved the recommendation (No. 136), and in 2018 the National Marine Fisheries Service and California Department of Fish and Wildlife authorized the expansion of the monitoring under Section 10(a)1(A) Scientific Collecting Permit # 16417-2R and California Department of Fish and Wildlife Scientific Collecting Permit # 11325.

In Water Year (WY) 2018 monitoring was conducted at 23 stations in the Guadalupe Watershed, including stations in the Guadalupe River, Guadalupe Creek, Los Gatos Creek, Calero Creek, and Alamitos Creek. Multipass depletion backpack electrofishing was conducted at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Guadalupe Watershed. Appropriately sized *O. mykiss* were tagged with a Passive Integrated Transponder (PIT) tags to study their movement within the Guadalupe Watershed.

Juvenile *O. mykiss* were present in Alamitos, Calero, and Guadalupe Creek during WY 2018, with 32 (0.2 *O. mykiss*/meter), 17 (0.14 *O. mykiss*/meter), and 66 (0.28 *O. mykiss*/meter) individuals captured in each creek respectively. No *O. mykiss* were detected in Guadalupe River or Los Gatos Creek. Based on the size range of fish collected, it can be deduced that production and successful summer rearing occurred and multiple age classes were present.

Seven species of non-native fish were observed amongst the five stations sampled, representing less than 4% of the total number of fish observed in WY 2018. The Guadalupe River and Los Gatos Creek had the highest percentage of non-natives (9.8% and 9.1% respectively). Of the seven species of non-natives, only the largemouth bass is considered a potential predator of *O. mykiss*.

This juvenile rearing monitoring is part of a continuing effort to better understand *O. mykiss* distribution and abundance in the Guadalupe Watershed. This report contains the results and analysis of the juvenile rearing monitoring conducted from WY 2004 – 2018.

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1. Introduction

The United States Army Corp of Engineers in partnership with the Santa Clara Valley Water District (SCVWD) constructed both the Guadalupe River Project (Downtown Project) and Upper Guadalupe River Project (UGRP). These projects together extend from approximately Norman Y. Mineta San Jose International Airport to Blossom Hill Road to protect downtown San Jose from Guadalupe River flooding. To offset the impacts of constructing the Downtown Project, the Guadalupe River Project Mitigation and Monitoring Plan (Downtown Project MMP) specified that a variety of mitigation be undertaken, including restoration of Guadalupe Creek from approximately Almaden Expressway to Masson Dam (Corps 2001a). The Downtown Project MMP also described the monitoring methods and measurable objectives for determining the success of mitigation. This included 10 years of monitoring for juvenile rearing of Central California Coast Steelhead (*Oncorhynchus mykiss*; *O. mykiss* for the remainder of the document) at 12 stations in the mainstem of the Guadalupe River and eight stations within Guadalupe Creek to demonstrate whether the associated measurable objective was being met: "The Guadalupe River must continue to support juvenile rearing at a level that is consistent with pre-project conditions and environmental conditions not affected by the Guadalupe River Project." In water year (WY) 2018, SCVWD expanded the juvenile rearing monitoring to stations in Los Gatos Creek, Alamitos Creek, and Calero Creek to improve understanding of juvenile *O. mykiss* distribution and densities, collect genetic information, and implement an *O. mykiss* tracking study using Passive Integrated Transponders (PIT).

SCVWD conducted the required juvenile rearing monitoring from WY 2004 to 2013, and the measurable objective was met in each year. Instead of ending the monitoring, SCVWD recommended continuing and expanding it to better understand *O. mykiss* numbers and distribution throughout the Guadalupe River watershed. In WY 2013, the Downtown Project Adaptive Management Team (Guadalupe AMT) approved the recommendation (No. 136) to continue juvenile rearing monitoring at five of the previous monitoring stations on the Guadalupe River and expand the monitoring to 15 stations elsewhere in the watershed.

However, the Downtown Project permits did not authorize juvenile rearing monitoring at additional stations. From WY 2014 to WY 2017 juvenile rearing monitoring continued at a subsample of five of the original permitted stations (as flow conditions allowed) while the permits for monitoring at additional stations were acquired. Ultimately, additional monitoring in the Guadalupe River watershed was authorized under National Marine Fisheries Service (NMFS) Section 10(a)1(A) scientific collecting permit number 16417-2R and California Department of Fish and Wildlife (CDFW) Scientific Collecting Permit #11325 for the SCVWD's Fisheries and Aquatic Habitat Collaborative Effort (FAHCE) Adaptive Fishery Management Baseline Data Collection Project. These permits authorized annual sampling in the Guadalupe River, Coyote Creek, and Stevens Creek, but the Guadalupe River was the only watershed with a defined sampling strategy in place in time for monitoring in WY 2018.

To date, juvenile rearing monitoring results have been reported to the Guadalupe AMT in the annual Mitigation Monitoring Report (MMR) for the Guadalupe River Projects. Beginning in WY 2018, monitoring results will be reported in a stand-alone document to facilitate distribution to and review by FAHCE stakeholders as well as the Guadalupe AMT.

2. Methods

2.1 Station Selection

A total of 23 stations within the Guadalupe River watershed were sampled between October 16, 2018 and November 6, 2018. To provide continuity from the previous monitoring on Guadalupe River and Guadalupe Creek and maintain a long-term dataset, WY 2018 sampling occurred at a subset of locations from WY 2004-2017 monitoring. In addition, new sampling stations were identified to expand the survey area using stratified random selection, and each sampling station, whether previously sampled or new, was given a unique identification number. Private lands were removed from the random selection process. Only areas of SCVWD ownership or easement, or

lands owned by other government agencies, were included to ensure sampling reaches could be easily accessed for multiple years to come. The rationale for station selection in each sub-watershed is described further below.

Guadalupe River

From 2004-2017, 12 stations were sampled on the mainstem of the Guadalupe River. These stations were distributed between Airport Parkway and the Highway 280 overcrossing near Grant Street. These stations were spaced approximately 450 m apart. The AMT recommendation for continuing juvenile rearing monitoring in the Guadalupe River watershed specified that five of the original 20 monitoring stations would continue to be sampled. The permits issued for conducting this work only allow a maximum of six stations to be sampled in each sub-watershed, so it was determined that for better spatial distribution throughout the entire Guadalupe River that the number of previously sampled stations be reduced to four. This allowed two additional stations be sampled in the upper portions of Guadalupe River up to the Alamitos Drop Structure, in areas not previously sampled. Stations 3, 6, 9, and 12 were originally selected to provide equal distribution throughout the previously sampled reach (Guadalupe mainstem from Airport Parkway to Highway 280); however, stations 6, 5, and 7 were unsafe to sample due to homeless activity in the area, so station 8 was selected. To randomly select the two remaining monitoring stations, the 10 km of mainstem Guadalupe River upstream of the original Downtown Project monitoring reach was broken into 10 1-km reaches. Two of the ten reaches were randomly selected using a random number generator. Those reaches were broken into 25 40-m stations, and a station was randomly selected using a random number generator in each reach. The previously sampled (WY 2004-2013), continuously sampled (WY 2004-2018), and new sampling stations (WY 2018) with unique station identifications numbers are mapped in Figure 1.

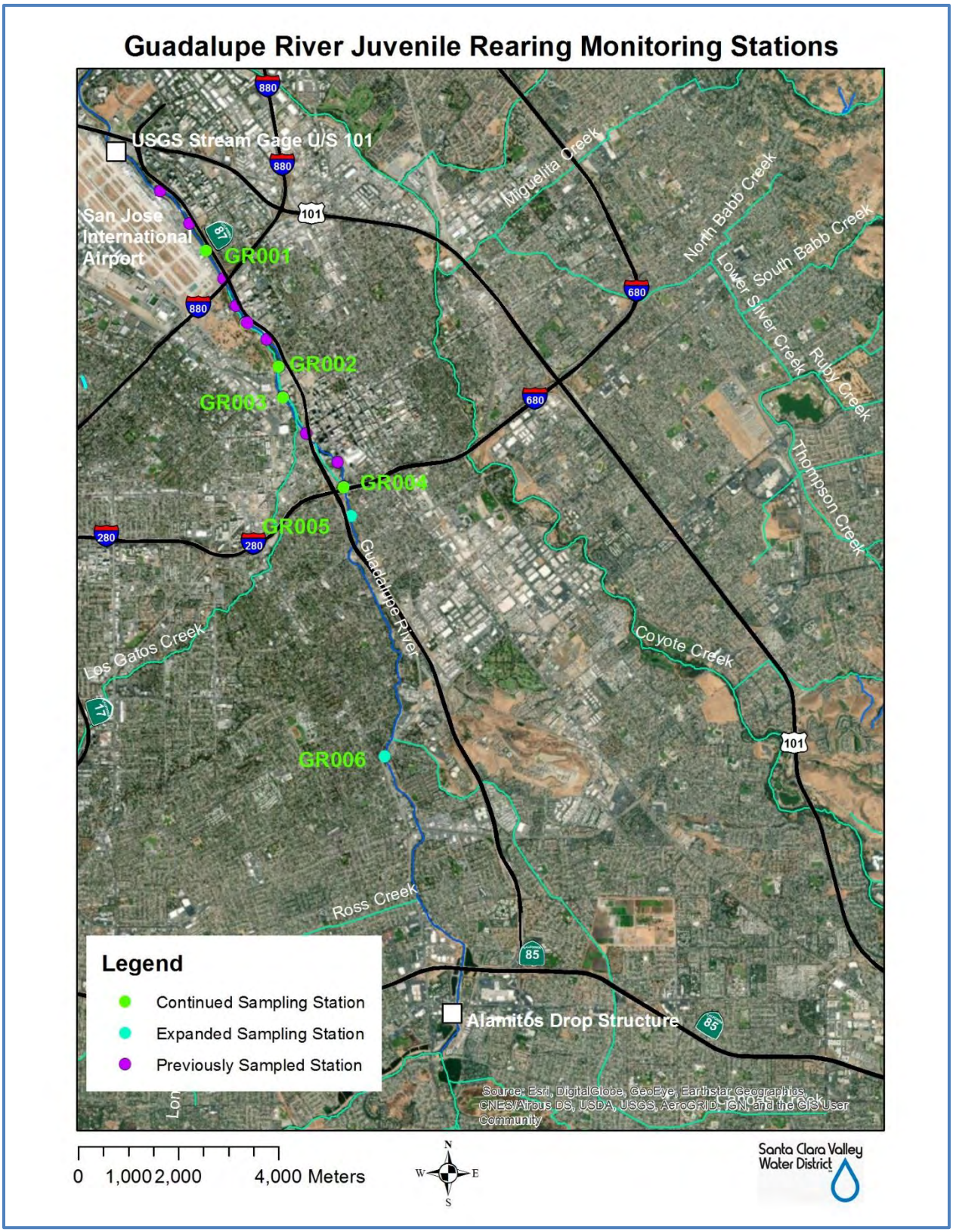


Figure 1: Guadalupe River juvenile rearing monitoring stations.

Guadalupe Creek

From 2004-2017, eight stations were sampled on Guadalupe Creek. These stations were distributed between Almaden Expressway and Stream Gage 43 (near the intersection of Shannon and Hicks Road). In previous reports these stations were numbers 13-20, a continuation of the Guadalupe River station numbers. In order to maintain a continuous dataset with the WY 2004-2017 monitoring, four of the previous sampling stations were selected for continued monitoring: Stations 14, 16, 18, and 20, which were respectively renamed as Stations GC001, GC002, GC003, and GC004. Two additional stations were selected on the remaining 4 km of Guadalupe Creek upstream of the area monitored for the Downtown Project to Guadalupe Reservoir. To randomly select the stations, the area was broken into four 1-km reaches. Two of the four reaches were randomly selected using a random number generator. Each 1-km reach was then broken into 25 40-m stations, and stations were randomly selected using a random number generator. The previously sampled, continuously sampled, and new sampling stations are mapped in Figure 2.

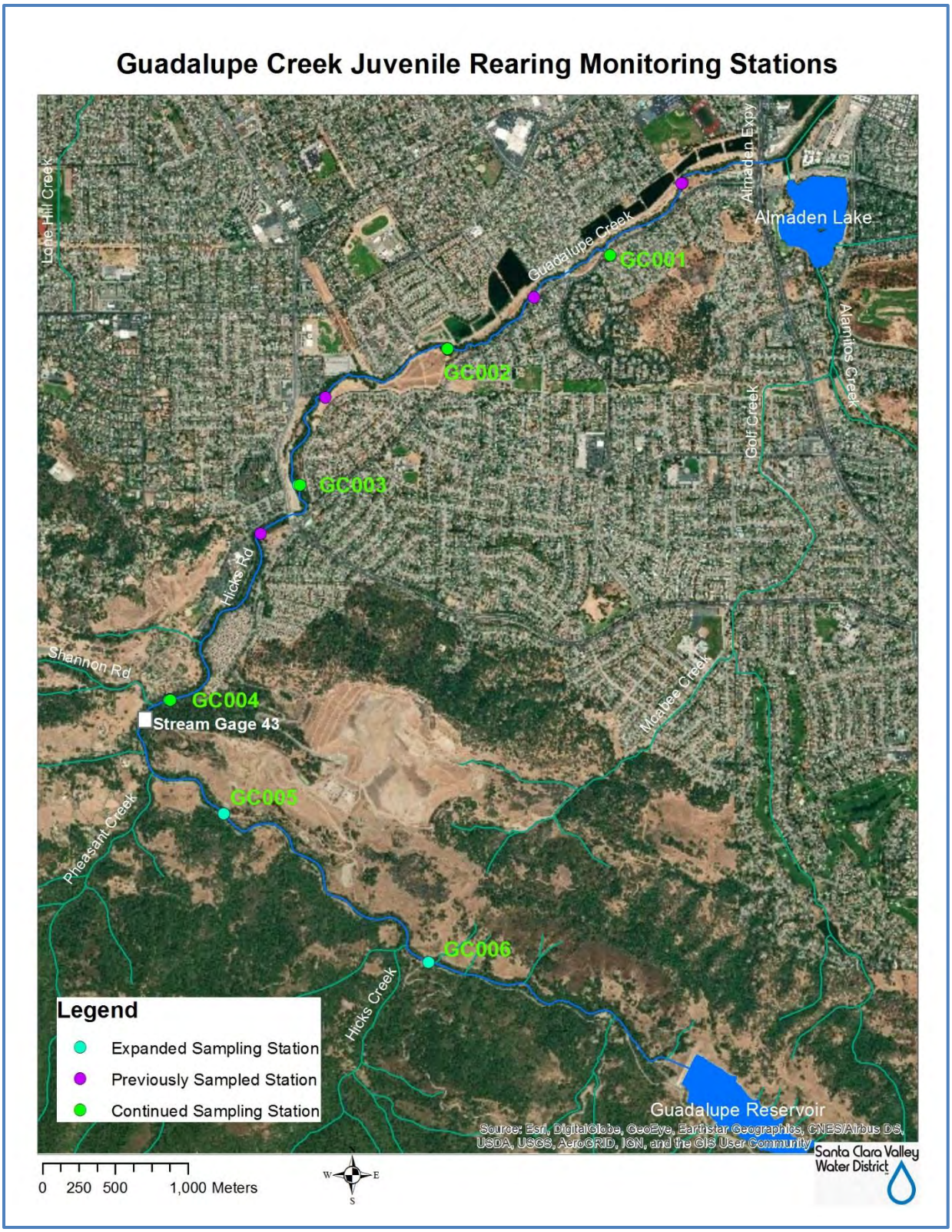


Figure 2: Guadalupe Creek juvenile rearing stations.

Los Gatos Creek

WY 2018 was the first year juvenile rearing sampling occurred on Los Gatos Creek. Four stations were randomly selected to represent the approximately 9 km reach of Los Gatos Creek from the confluence with the Guadalupe River to the Camden Avenue Drop Structure, which is the upstream extent of anadromy. To randomly select the stations, the area was broken into nine 1-km reaches. Four of the nine reaches were randomly selected using a random number generator. Those four 1-km reaches were broken into 25 40-m stations, and each station was randomly selected using a random number generator. They were then assigned station identification numbers 1-4. The results of the station selection can be seen in Figure 3.

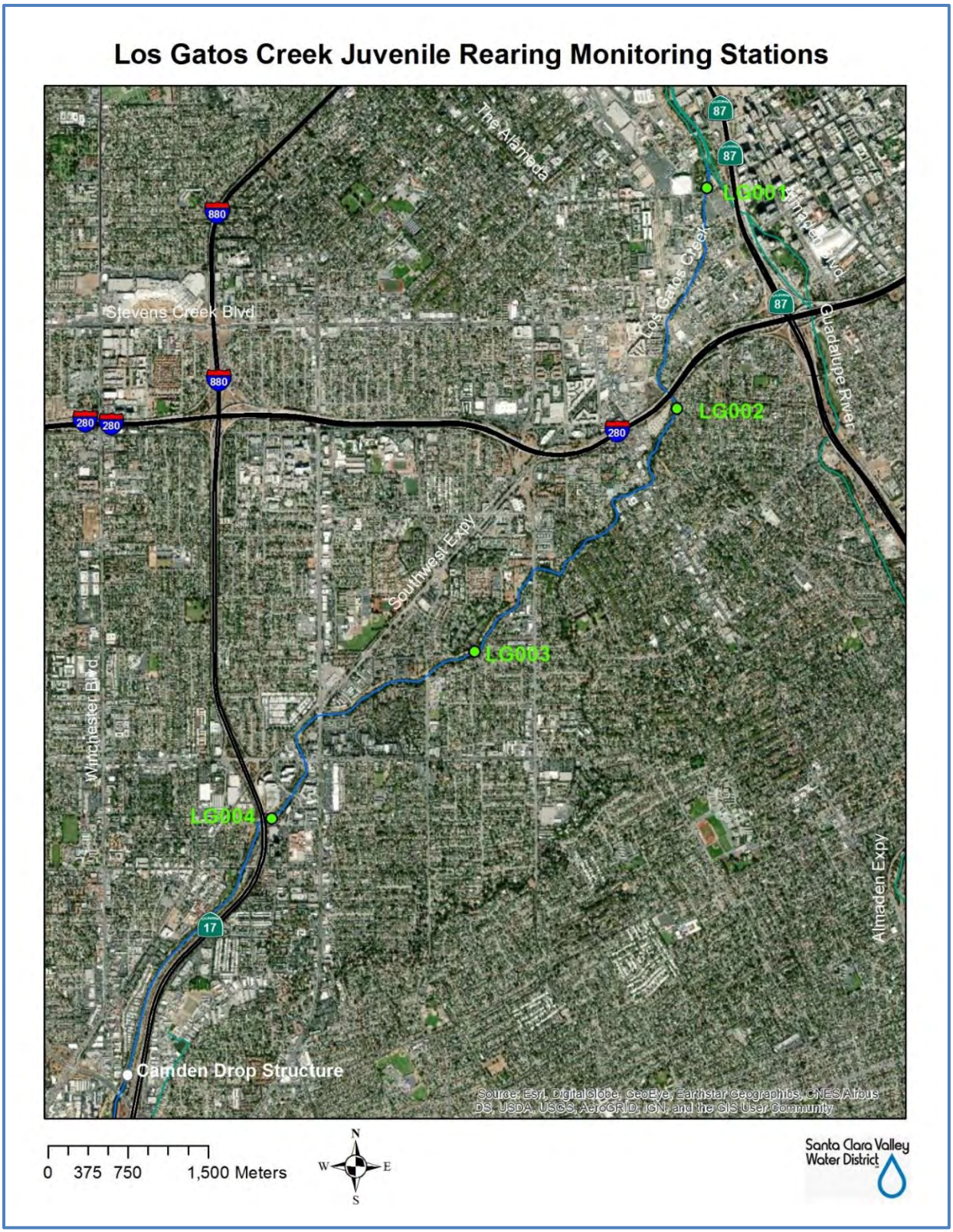


Figure 3: Los Gatos Creek juvenile rearing stations.

Alamitos Creek

WY 2018 was the first year juvenile rearing sampling occurred on Alamitos Creek. Four stations were randomly selected to represent the approximately 11 km of Alamitos Creek from the confluence with Lake Almaden to the base of the dam at Almaden Reservoir. To randomly select the stations, the area was broken into 11 1-km reaches. Four of the 11 reaches were randomly selected using a random number generator. Those reaches were broken into 25 40-m stations, and each station was randomly selected using a random number generator. They were assigned station identification numbers 1-4. Selected stations are mapped in Figure 4.

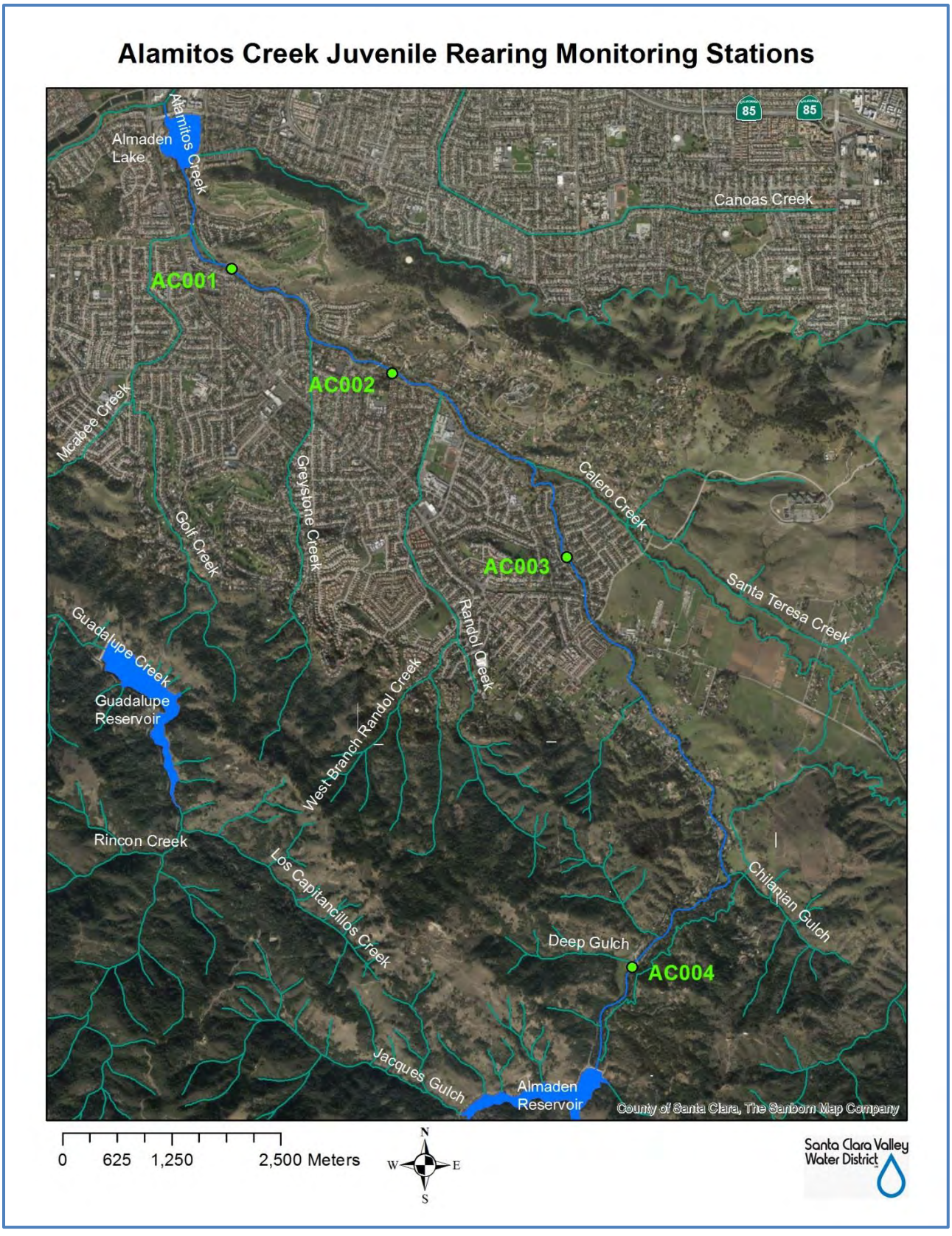


Figure 4: Alamitos Creek juvenile rearing sampling stations.

Calero Creek

WY 2018 was the first year juvenile rearing sampling occurred on Calero Creek. Three sampling stations were selected to represent the approximately 6 km portion of Calero Creek from the confluence with Alamitos Creek to the base of the dam at Calero Reservoir. To randomly select the stations, the area was broken into six 1-km reaches. Three of the six reaches were randomly selected using a random number generator. Those 1-km reaches were broken into 25 40-m stations, and each station was randomly selected using a random number generator. They were then assigned station identification numbers 1-3. Selected stations are mapped in Figure 5.

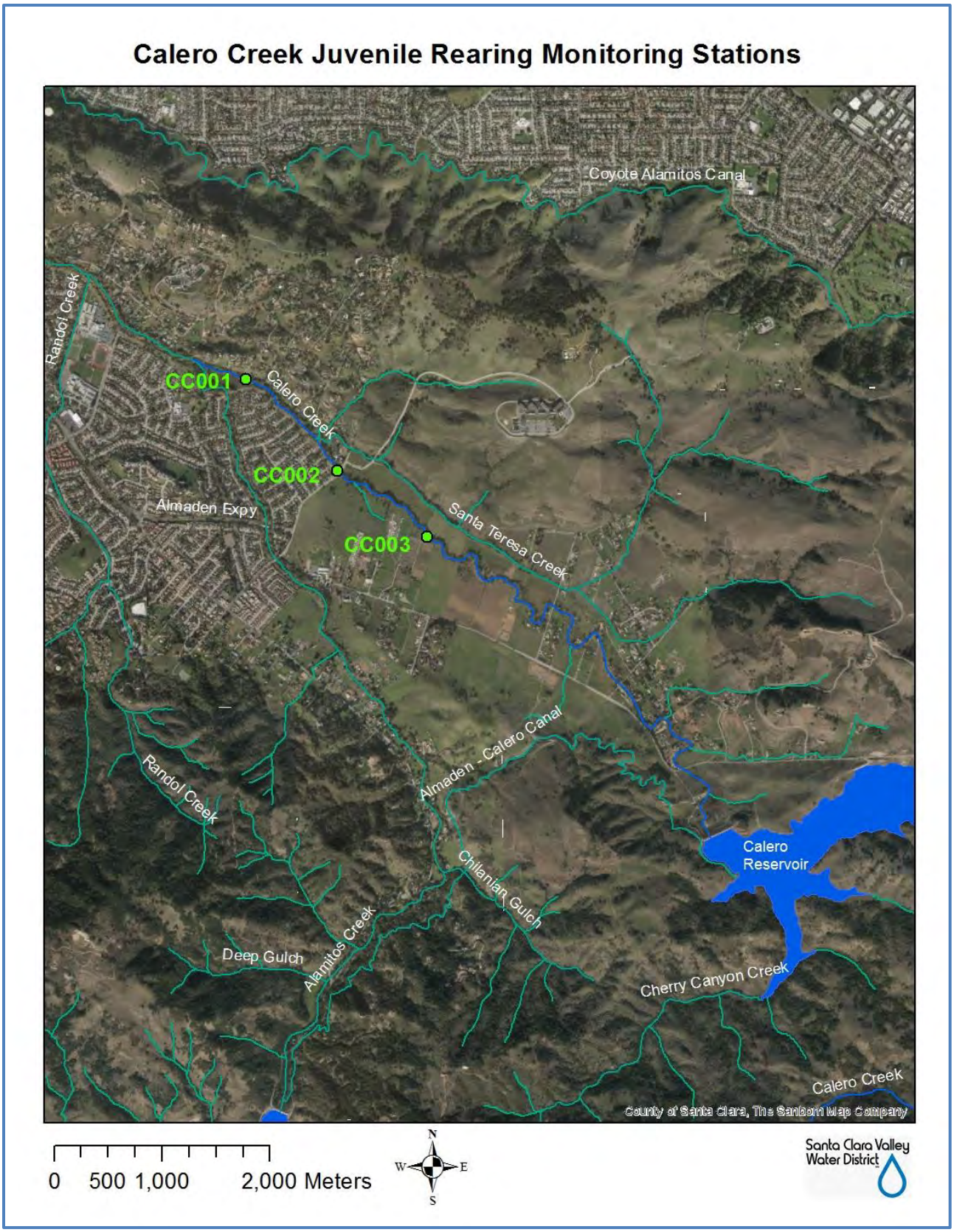


Figure 5: Calero Creek juvenile rearing sampling stations.

2.2 Sampling Methods

Each sampling station was 40-m except for one 35-m station on the Guadalupe River (GR002), that had to be shortened due to excessive water depth. Each station was set as close as possible to the randomly selected point to include at least two distinct habitat types, described below. Multi-pass depletion backpack electrofishing was used for juvenile rearing monitoring (Johnson et al. 2007). This method allowed for: consistency with previous juvenile rearing monitoring methods, population estimates to be extrapolated, and a variety of habitat types to be sampled.

Habitat Typing

Each sampling reach was 40-m in length. Each 40-m reach was habitat typed using the classifications described in Table 1. Each sampling station was selected to contain at least two distinct habitat types. Habitat typing followed Ode (2007) for habitat type descriptions (Table 1). Average wetted width and depth was estimated and the presence of any anthropogenic influences (bridge, dam, etc.) was noted. Prior to the start of sampling, ambient conditions (weather) were noted and water quality (dissolved oxygen, conductivity, and temperature) were collected at the downstream end of the sampling stations. Ocular estimates of percent cover of macrophytes/emergent vegetation, boulders, woody debris, undercut banks, overhanging vegetation, submerged roots (live and dead), and artificial structures were recorded for each sampling station (Table 2). Each habitat feature was ranked on a 0-4 point scale described below, with 0 being absent and 4 being a very heavy presence (Table 2). Primary and secondary substrate types were determined based upon ocular estimates (Table 3; Ode 2007).

Table 1: Habitat type classifications (Ode 2007).

Habitat Type	Description
Cascades	Short, high gradient drop in streambed elevation often accompanied by boulders and considerable turbulence.
Falls	High gradient drop in elevation of the streambed associated with an abrupt change in the bedrock.
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.
Riffles	Shallow sections where the water flows over coarse streambed particles that create mild to moderate surface turbulence.
Step-Run	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope.
Runs	Sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool.
Glides	A section of stream with little or no turbulence, but faster velocity than pools.
Pool	A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Table 2: Ocular estimate scale (Ode 2007).

Scale	0	1	2	3	4
Percent Coverage	0%	<10%	10-40%	40-75%	>75%
Descriptor	Absent	Sparse	Moderate	Heavy	Very Heavy

Table 3: Substrate classes

Particle Size	Size Category
Boulder	> 250 mm
Cobble	65-250 mm
Gravel	2.0-65 mm
Sand	<2.0 mm (gritty texture)
Silt/Clay	Not gritty
Bedrock	No individual particles

Electrofishing

Block nets were installed at both the upstream and downstream ends of sampling reaches to block immigration into and emigration out of sampling reaches. Electrofishing commenced from down to upstream and worked laterally across the stream to ensure all portions of the wetted width were sampled. Smith-Root LR24 Backpack Electrofishing Units were used at all sampling stations. The LR24 quick set option was used to establish the initial power and waveform settings. The quick set output was verified with conductivity readings. Electrofishers were run using direct current, at a frequency of 30 HZ, duty cycle of 12%, and voltage that ranged between 150 and 190 volts. The electrofisher operator was flanked by two netters. Verbal communication and spatial awareness were used to ensure the entire width of the stream was covered. Triple-pass depletion elecotrofishing methods were deployed at all stations unless conditions did not allow (temperature constraints); these sites are pointed out in the Results and Discussion section.

Fish Processing

Fish were held in aerated dark-colored containers during processing. Length measurements were recorded to the nearest millimeter at the fork of the tail (fork-length). For each pass, up to 30 individuals of each species were measured, and all other individuals of that species were counted for a total number.

Carbon dioxide (CO_2) was administered to *O. mykiss* using Alka-Seltzer Gold, in doses to induce light narcosis (1 tablet per 2.5 liters of stream water). *O. mykiss* were exposed to the anesthesia for no more than 5 minutes. *O. mykiss* were observed for listing, and upon listing were removed from the anesthetizing solution, weighed, measured, tail-clipped for a genetic sample, and PIT tagged if large enough (≥65 mm fork-length).

Fin clips were taken for genetic analysis of all *O. mykiss* from the caudal fin. Clips were a 1-2 mm square. Medical grade scissors used to collect the clips were sterilized with an alcohol dilution with a final concentration of 60-80% isopropyl. Tissue samples were placed in sterile chromatography paper and placed in a labeled envelope denoting the field specimen number, species, stream, stream location, date, and fork-length. Tissues collected will be sent to the NMFS Southwest Fisheries Science Center. After exposure to the anesthesia and handling, fish were placed in an aerated dark-colored live well, then moved to an in-channel live car for recovery, and then released.

All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure. *O. mykiss* of 65 mm in fork-length or greater were tagged with a Passive Integrated Transponder (PIT) tag. Biomark single-use preloaded needles were used in the tagging process. *O. mykiss* greater than or equal to 65 mm fork-length received 12 mm half-duplex PIT tags. *O. mykiss* larger than 150 mm fork-length received 23 mm tags. The permits allow for fish greater than 100 mm to be tagged with 23 mm tags, but to be conservative of the fishes' welfare, the minimum size was increased to 150 mm. PIT tags were scanned prior to insertion to verify they were viable. PIT tag numbers and associated biological data for each fish is included in Appendix A.

2.3 Data Analysis

MicroFish 3.0 was used to calculate population estimates for each station using a maximum-likelihood iterative process; the associated standard errors and 95% confidence intervals (95% CI) are reported. This method uses the number of fish captured (n) and the difference in capture between electrofishing passes (i.e., depletion

rate) to calculate an estimate of fish likely to have been present but not captured, thus generating a population estimate (N) for each station. Population estimates are restricted to the sampled areas and are only an index of the overall population. If the number of a particular species was too low (i.e., only one fish was captured) or all fish of a particular species were captured on the first pass, then maximum-likelihood population estimate could not be produced. If the lower confidence interval was less than the total catch it was set equal to total catch, as it is certain at least that many fish were present in the sampling reach. These calculations assume emigration and immigration were prevented by the erection of upstream and downstream block nets. It is assumed that shocking efficiency did not change between passes and that staff did not become more efficient using the equipment, nor did fish learn to avoid the electrical field between passes. To enable comparison of WY 2018 results with that of previous monitoring years, when different reach lengths may have been sampled, results were standardized to catch per meter.

3. Results and Discussion

3.1 Guadalupe River

Sampling occurred at six stations on the Guadalupe River on October 25, 29, and 31, 2018. Most sampling days were sunny and clear, but overcast conditions occurred on the 25th. Flows at the United States Geological Survey (USGS) gage upstream of Highway 101 (USGS #11169025), which provides the best representation of the juvenile rearing stations on the mainstem Guadalupe River, were approximately 28 cubic feet per second (cfs) during all sampling days. Stations located upstream of Los Gatos Creek (GR004, GR005, and GR006) will have flow lower than what occurs at Highway 101.

GR001

This was the most downstream station sampled on the Guadalupe River and was one of the stations that had been sampled during the previous monitoring effort (when it was referred to as Site 3). This station is low gradient. A dense riparian corridor is present

(Figure 6), but the channel is situated between two levees and urban development. The sampling station was 40-m in length with an average wetted width of 7.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and run. Each made up 50 % of the sampled area. The primary substrate was gravel with a secondary substrate of cobble. Water quality and habitat complexity at the time of sampling are summarized in Table 4.



Figure 6: Photos of station GR001, looking upstream (left) and looking downstream (right).

Table 4: Guadalupe River station GR001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
881	16.85	10.24	18.9			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	0	2	2	2	2	0

Fish captured and associated population estimates are summarized in Table 5. Four species of fish were captured: prickly sculpin (*Cottus asper*), riffle sculpin (*Cottus gulosus*), Sacramento sucker (*Catostomus occidantalis*) and green sunfish (*Lepomis*

cyanellus). The most abundant species was prickly sculpin (n=18). No *O. mykiss* were captured.

Table 5: Number captured and Population estimate at Station GR001 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
Prickly sculpin	Yes	18	18	0.505	18-19
Riffle sculpin	Yes	1	-	-	-
Sacramento sucker	Yes	1	-	-	-
Green sunfish	No	3	3	1.271	3-8

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR001 had low capture rates (23 total fish) and high rates of depletion per pass causing the population estimates to equal the number of fish captured. Of the four species captured, three are considered native.

Station GR001 has 14 years of comparable data (2004-2017, except drought conditions precluded sampling at this station in 2014). Figure 7 shows the standardized capture of *O. mykiss* between 2004 and 2018. This station historically has low production of *O. mykiss*: of the 14 years of data, *O. mykiss* were only collected in four of the years, and the highest capture rate (in 2005) was 0.10 fish per meter. The average *O. mykiss* capture rate for this station is 0.02 fish per meter. These results indicate that *O. mykiss* occurrence in this downstream portion of the Guadalupe River is very low, inconsistent, and potentially that recolonization has not occurred after the severe drought conditions and channel drying that occurred in 2014-2016.

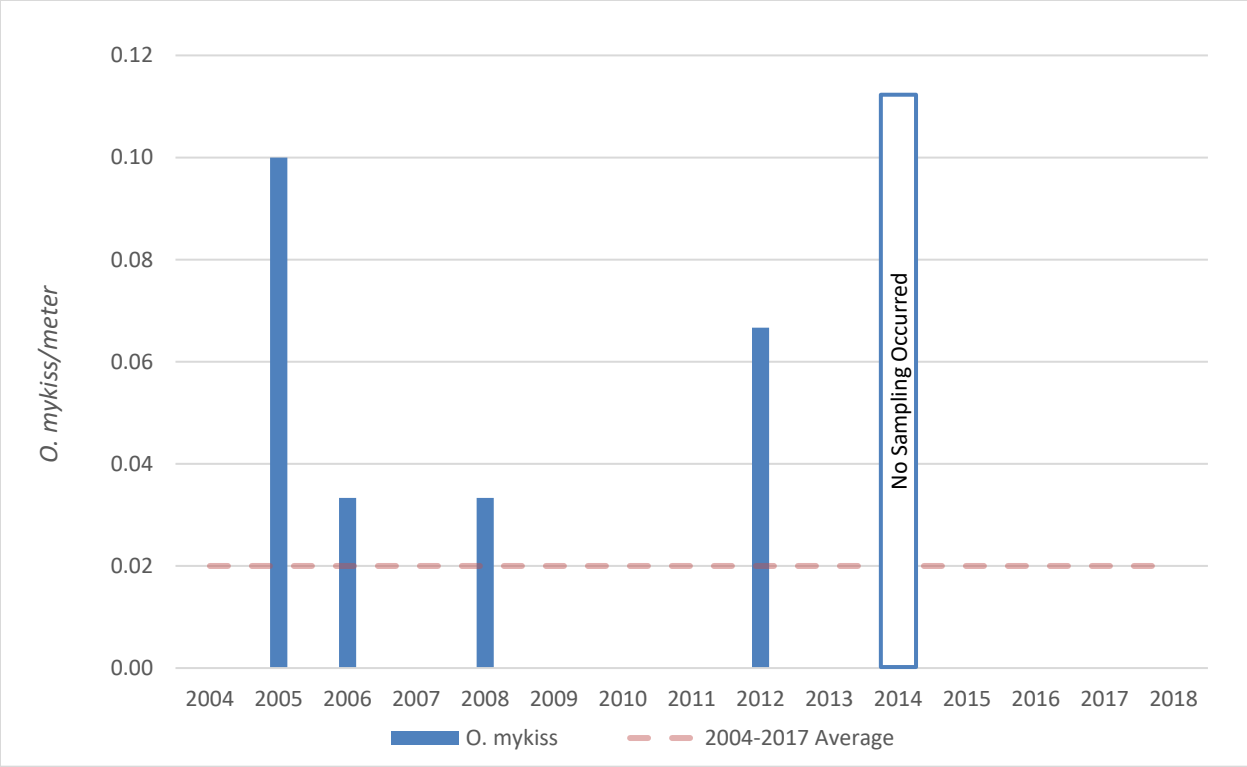


Figure 7: Station GR001 (previously Station 3) standardized *O. mykiss* capture 2004-2018.

GR002

This station was a continued sampling location previously referred to as Site 8. This station is bordered by the Guadalupe Park and Gardens and Highway 87. A dense riparian corridor is present, but there is a high level of anthropogenic disturbances (homeless, trash and debris). The sampling station was only 35 m in length (rather than 40 m) due to a pool at the downstream end and portions of the glide on the upstream end that were too deep to sample. The average wetted width was 6.5 m and the average depth was 0.5 m. Two habitat types were present within the station: riffle and glide (Figure 8). The riffle habitat was 71% of the reach; glide habitat was 29%. The primary substrate was large cobble with a secondary substrate of gravel. Water quality and habitat complexity at the time of sampling is summarized in Table 6.



Figure 8: Photos of station GR002, looking upstream (left) and looking downstream (right).

Table 6: Guadalupe River station GR002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
803	17.03	8.46		22.5		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	3	1	2	3	3	0

Prickly sculpin were the only species collected. Fish captured and associated population estimates are summarized in Table 7. No *O. mykiss* were captured at this sampling station. Station GR002 had low species diversity and the population estimate equaled the number of fish captured. No non-native fish were collected.

Station GR002 has 12 years of comparable data (drought conditions in 2014-2015 and higher than normal flows in 2017 precluded sampling at this station in those years). Figure 9 shows the standardized capture of *O. mykiss* between 2004 and 2018. *O. mykiss* were collected in eight of the 12 years of data, and the highest fish per meter observed was in 2008 at 0.60 fish. The average *O. mykiss* per meter based on the

2004-2017 sampling period was 0.15 fish. Previous sampling results indicate that juvenile *O. mykiss* used this site in most years. Current results indicate that rearing in this portion of the Guadalupe River is extremely low or recolonization has not occurred after the drought conditions (including dry-backs) starting in 2014.

Table 7: Number captured and population estimate at Station GR002 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
Prickly sculpin	Yes	24	24	0.752	24-26

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

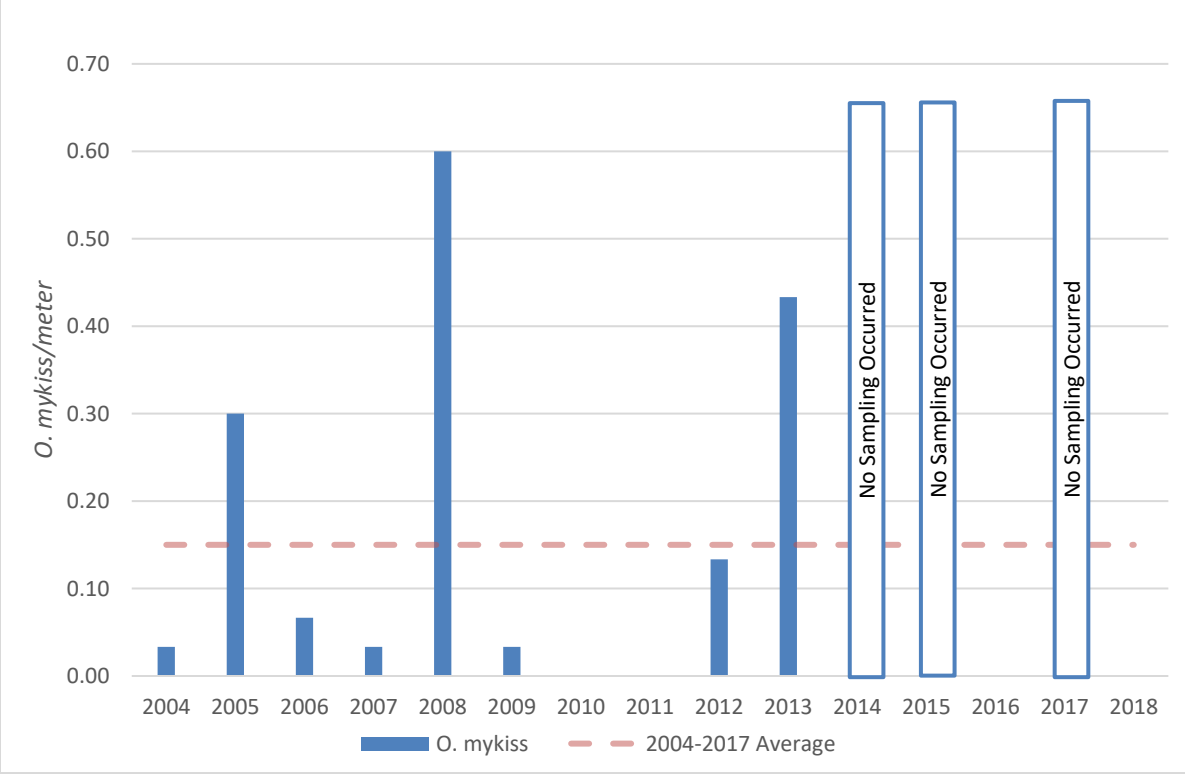


Figure 9: Station GR002 (previously Station 8) standardized *O. mykiss* capture 2004-2018.

GR003

This station was a continued sampling location previously referred to as Site 9. This station includes the St. John Street passage remediation project, which created riffle habitat and added large woody debris to remove a fish passage barrier. A portion of the

station was under the St. John Street Bridge. The sampling station was 40 m in length with an average wetted width of 8.5 m and an average depth of 0.45 m. Two habitat types were present within the station: riffle and run (Figure 10). Each made up 50% of the station. The primary substrate was large cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 8.

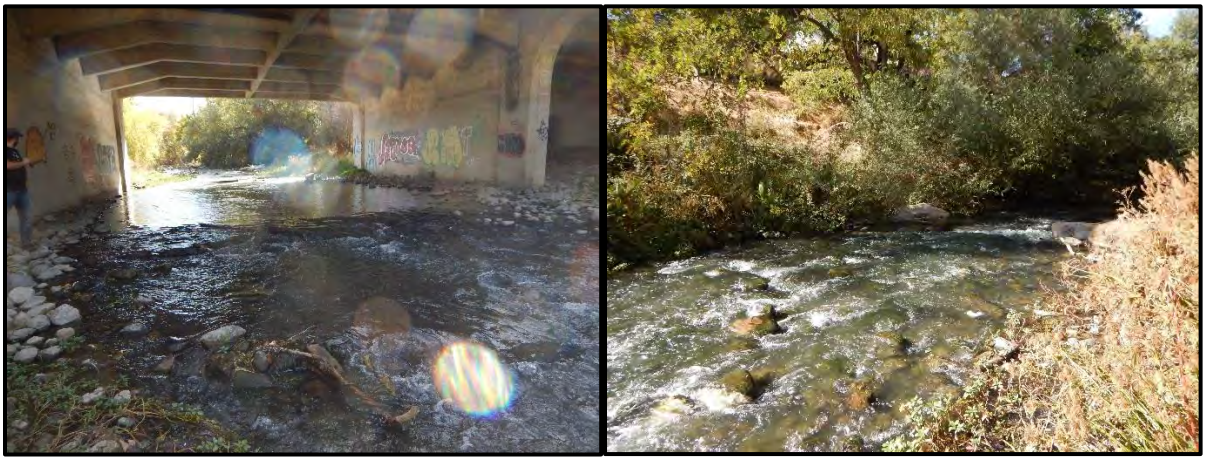


Figure 10: Photos of station GR003, looking upstream (left) and looking downstream (right).

Table 8: Guadalupe River station GR003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
613	17.00	10.23	20.0			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	4	1	0	1	1	4

Two sampling passes were conducted at this station; a third pass was not made due to increasing water temperature that had the potential to exceed the maximum water temperature allowed under the permitted sampling conditions (18.0°C). The four

species of fish captured were: California roach (*Hesperoleucus symmetricus*), prickly sculpin, Sacramento sucker, and mosquitofish (*Gambusia affinis*). The most abundant species encountered was California roach (n=41). Fish captured and associated population estimates are summarized in Table 9. No *O. mykiss* were captured at this sampling station.

Table 9: Number captured and population estimates at Station GR003 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	41	62	0	41-62
Prickly sculpin	Yes	23	23	0.968	23-25
Sacramento sucker	Yes	5	8	10.919	5-34
Mosquitofish	No	1	-	-	-

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR003 had the highest total capture of fish in the Guadalupe River (70 total fish). The maximum likelihood iterations indicate that the number of California roach and Sacramento sucker is likely higher than what was captured. Sampling conditions were difficult due to the width and the velocity in the riffle, and fish were likely missed during the passes.

Station GR003 has 13 years of comparable data (drought conditions precluded sampling at this station in 2014-2015). Figure 11 shows the standardized capture of *O. mykiss* between 2004 and 2018. Of the 13 years of data, *O. mykiss* were collected in seven of the years sampled and the highest fish per meter observed was in 2012 at 0.43 fish. The average *O. mykiss* per meter based on the 2004-2017 dataset for this station is 0.12 fish. Previous sampling results indicate that juvenile *O. mykiss* used this site in most years. No *O. mykiss* have been captured since the dry-backs in 2015. Current results indicate that rearing in this portion of the Guadalupe River is extremely low, variable, or recolonization has not occurred after the drought conditions (including dry-backs) starting in 2014.

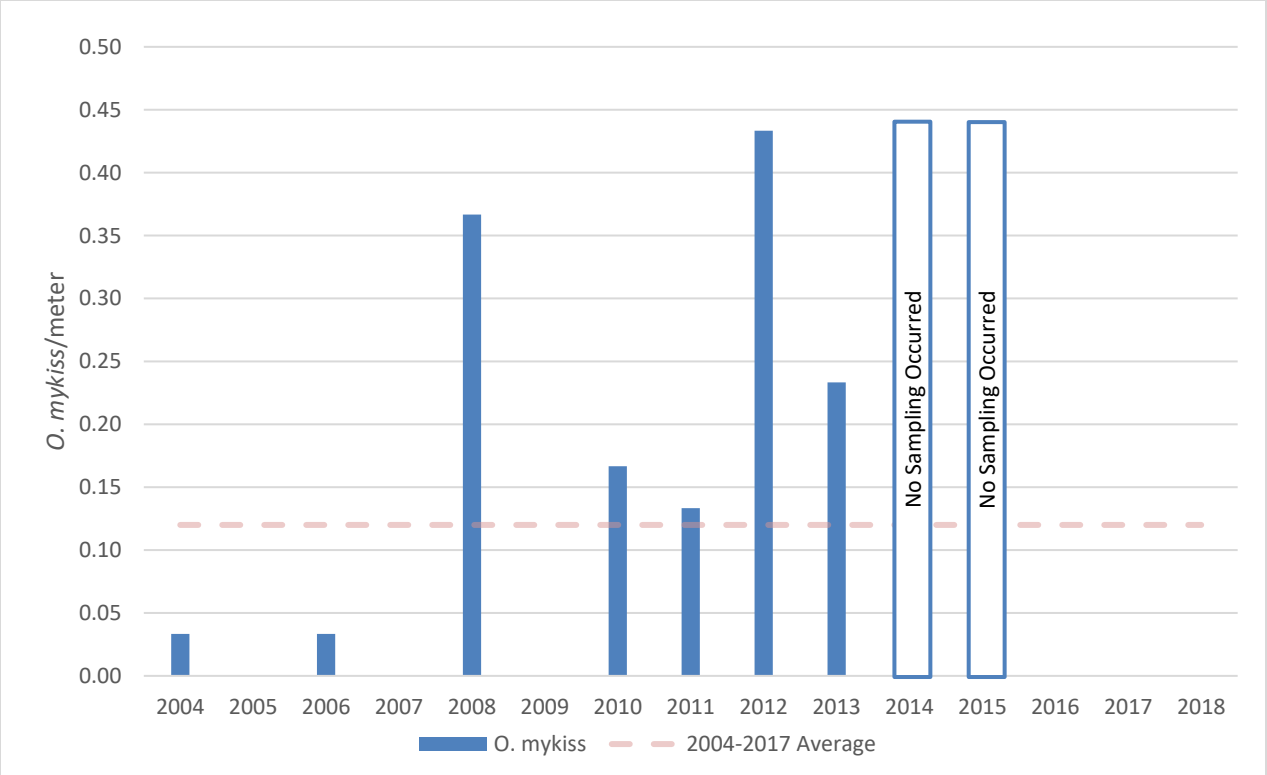


Figure 11: Station GR003 (previously Station 9) standardized *O. mykiss* capture 2004-2018.

GR004

This station was a continued sampling location. During the data collection effort between 2004 and 2017, this station was known as Site 12. This station falls within the Downtown Project's hardscaped reach. The channel bottom consists of cellular concrete mattress (CCM), with natural substrates deposited on the surface. The sampling station was 40 m in length with an average wetted width of 3.0 m and an average depth of 0.5 m. Habitat at the station was 90% run, 5% pool, and 5% riffle (Figure 12). The primary substrate was silt with a secondary substrate of boulders over the top of the CCM. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 10.



Figure 12: Photos of station GR004, looking upstream (left) and looking downstream (right).

Table 10: Guadalupe River station GR004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
817	16.38	6.62	55.0			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
4	2	1	0	0	0	4

The five species of fish captured were: California roach, prickly sculpin, Sacramento sucker, largemouth bass (*Micropterus salmoides*), and mosquitofish. The most abundant species encountered was Sacramento sucker (n=16). Fish captured and associated population estimates are summarized in Table 11. In station GR004 the maximum likelihood iterations indicate that the number of California roach and Sacramento sucker is likely higher than what was captured. No *O. mykiss* were captured at this sampling station.

Table 11: Number captured and population estimates at Station GR004 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	11	14	5.64	11-26
Prickly sculpin	Yes	1	-	-	-
Sacramento sucker	Yes	16	17	2.241	16-22
Largemouth bass	No	2	2	1.038	2-15
Mosquitofish	No	1	-	-	-

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR004 has 13 years of comparable data. As at previous sites, drought induced dry-backs occurred in this reach in 2015. Figure 13 shows the standardized capture of *O. mykiss* between 2004 and 2018. This station historically has low occurrence of *O. mykiss*. Of the 13 years of data, only two years had collection of *O. mykiss* with the highest fish per meter observed in 2012 at 0.20 fish. The average *O. mykiss* per meter based on the 2004-2017 dataset for this station is 0.03 fish. Results indicate that juvenile rearing in this portion of the Guadalupe River is historically extremely low.

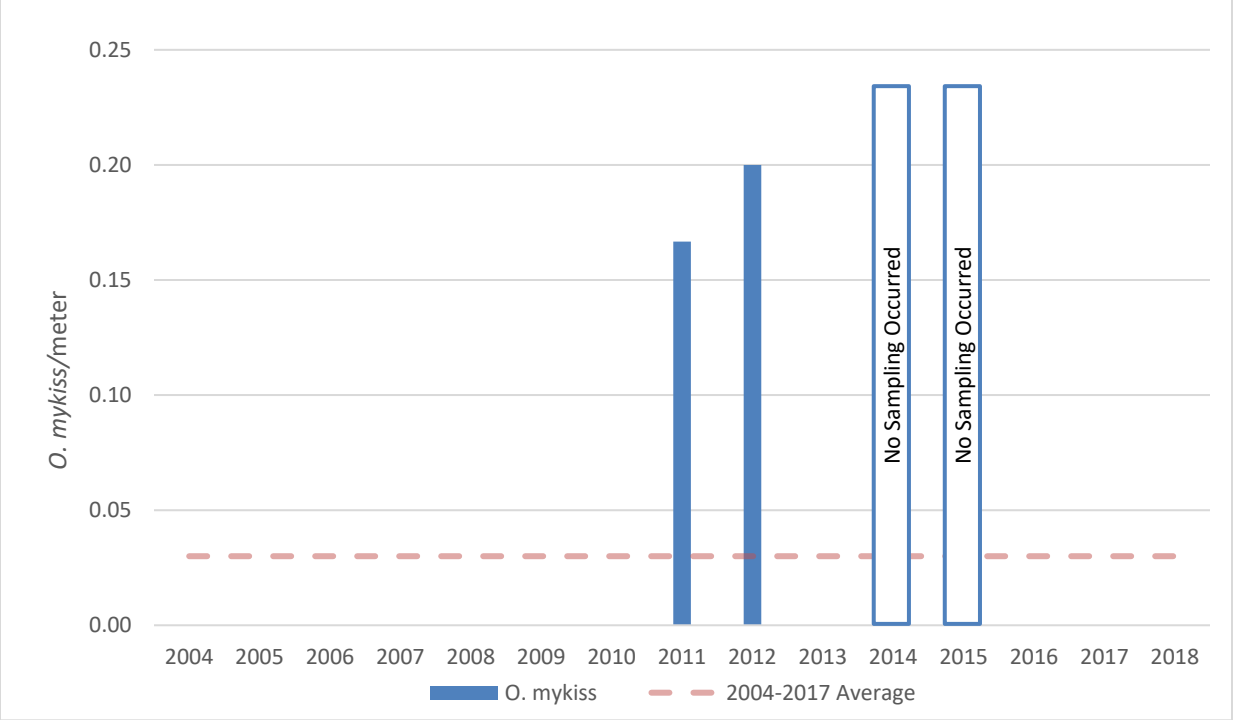


Figure 13: Station GR004 (previously Station 8) standardized *O. mykiss* capture 2004-2018.

GR005

This is a new (WY 2018) monitoring station, directly downstream of the Virginia Street bridge. The sampling station was 40 m in length with an average wetted width of 8.0 m and an average depth of 0.7 m. Three habitat types were present within the station: riffle, run, and cascade (Figure 14). The “cascade” portion of the habitat was the result of an unpermitted, human-made rock and rubble creek crossing placed in the creek. The crossing was reported and removed by a volunteer group following sampling activities. Homeless camps were present in the area. The riffle including the small “cascades” made up 25% of the habitat with the run making up the remaining 75%. The primary substrate was silt with a secondary substrate of boulders. A lot of debris and fallen limbs were present in the lower portion of the station limiting visibility of the substrate. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 12.



Figure 14: Photos of station GR005, looking upstream (left) and looking downstream (right).

Table 12: Guadalupe River station GR005 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
863	15.25	8.83	52

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	3	0	2	1	2	4

The third electrofishing pass was abbreviated as an adult Chinook salmon (*Oncorhynchus tshawytscha*) was captured (Figure 15). The Chinook salmon was estimated at 650 mm and was adipose fin-clipped, indicating that it was of hatchery origin and had strayed into Guadalupe River. The Chinook salmon was not observed until the third pass. All sampling ceased at the station after the Chinook salmon was captured. A total of seven species of fish were captured: California roach, Sacramento sucker, Chinook salmon, common carp (*Cyprinus carpio*), green sunfish, largemouth bass, and mosquitofish. The most abundant species encountered was Sacramento sucker (n=9). Fish captured and associated population estimates are summarized in Table 13. No *O. mykiss* were captured at this sampling station.



Figure 15: Hatchery stray Chinook salmon captured in GR005.

Table 13: Number captured and population estimates at Station GR005 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	8	8	0.769	8-10
Sacramento sucker	Yes	9	9	0.947	9-11
Chinook salmon[1]	No	1	-	-	-
Common carp	No	1	-	-	-
Green sunfish	No	3	5	9.677	3-32
Largemouth bass	No	1	-	-	-
Mosquitofish	No	4	6	0	4-6

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station GR005 the maximum likelihood iterations indicate that the number of green sunfish and mosquitofish was likely higher than what was captured. This station had the highest species richness on the Guadalupe River, but consisted of 71% non-native species.

GR006

This is a new (WY 2018) monitoring station. It is the most upstream station on the mainstem Guadalupe River and is within the UGRP Segment 10B, where geomorphic and riparian mitigation has been implemented. The sampling station was 40 m in length with an average wetted width of 2.0 m and an average depth of 0.2 m. Habitat at the station was 60% riffle and 40% glide (Figure 16). The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 14.

[1] While Chinook salmon are native to California, there is no historical data suggesting they were historically present in Santa Clara County. Genetic analysis indicates that Chinook salmon in the Guadalupe River watershed are hatchery strays (Garcia-Rossi and Hedgecock 2002). For this analysis, Chinook salmon were considered a non-native species.



Figure 16: Photos of station GR006, looking upstream (left) and looking downstream (right).

Table 14: Guadalupe River station GR006 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
553	16.58	9.70	26.5			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
4	2	0	1	2	2	0

Four species of fish were captured: prickly sculpin, Sacramento sucker, largemouth bass, and mosquitofish. The most abundant species encountered was Sacramento sucker (n=16). Fish captured and associated population estimates are summarized in Table 15.

Table 15: Number captured and population estimates at Station GR006 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
Prickly sculpin	Yes	1	-	-	-
Sacramento sucker	Yes	16	16	0.9	16-18
Largemouth bass	No	1	-	-	-
Mosquitofish	No	1	-	-	-

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR006 had low capture rates and the population estimates equaled the number of fish captured. Based on these results, it is not expected that other species of fish were present that were not accounted for in this census.

Discussion

No *O. mykiss* were collected at any of the sampling stations on the Guadalupe River in WY 2018. Based on the previous Guadalupe River Project monitoring (WYs 2004-2017), it is not uncommon for this species to be absent at individual sampling stations on mainstem Guadalupe River. Since 2004, no sampling station in the Guadalupe River has consistently had *O. mykiss*. The 2018 sampling effort is the fourth continuous year with no detections, the longest period with no *O. mykiss* detections since juvenile rearing monitoring began. Habitat is present that could support rearing of *O. mykiss*.

It is not entirely clear why juvenile *O. mykiss* have not been detected in Guadalupe River in recent years. There have been no detectable changes in physical habitat on the Guadalupe River that would trigger such a decrease. All stations sampled had some sort of habitat complexity (i.e., undercut banks, large woody debris, or submerged roots) that could be used as *O. mykiss* refugia, and riffle habitat that should support fast-water feeding requirements. The measurable objectives for streamside vegetation in the Downtown Project are being met, and other fisheries monitoring indicators, such as suitable habitat area, have indicated that habitat is available and consistent with unaltered index reaches (SCVWD and Stillwater Sciences 2018). Previous MMRs have discussed the influence that sampling timing appears to have on the number of *O. mykiss* detected in mainstem Guadalupe River. In years that sampling occurred after a

rain event, more *O. mykiss* were observed, but in each year between 2004-2013 fish were detected in portion of the Guadalupe River (SCVWD and Stillwater Sciences 2013). In 2018 sampling occurred prior to any storm events that would have stimulated downstream fish migration. Data collected in December 2018 on a Vaki RiverWatcher located on the Guadalupe River at the Alamitos Drop Structure also supports the hypothesis that rain events may influence abundance in the Guadalupe River. After the first rain event, juvenile *O. mykiss* were observed moving downstream through the counting system (SCVWD 2019). In addition, sampling by Hobbs et al. (2014) which occurred later in the season in December 2013, and January, February, and March 2014, also yielded *O. mykiss* on the mainstem Guadalupe River. *O. mykiss* PIT tagged on the Guadalupe River by Hobbs et al. (2014) were recorded out-migrating in February and March of the same year. Together, these results could potentially indicate that the Guadalupe River is not a primary producer of *O. mykiss*, or preferred area of summer rearing of *O. mykiss*, but serves as a migration corridor or for winter rearing and smoltification. In the future, SCVWD will attempt to monitor juvenile rearing prior to any storm events to help control for the influence that downstream fish migration likely has on capture rates.

Patterns in the capture of other native fish add to the evidence that fish populations have not yet rebounded after the severe drought conditions in 2014-2016. Prior to 2014, the average annual catch of all native fish in the four consistently sampled stations was 4.48 fish per meter (California roach were particularly plentiful). In 2015 and 2016, some stations yielded zero fish or were completely dry. From 2015 to 2018 the average annual catch was 0.56 fish per meter. In 2018 the average total catch was 0.69 fish per meter. This is higher than the post-drought average, but still much lower than what was historically observed. It is expected that over time, after *O. mykiss* and other native fish populations rebound in upper watershed tributaries, *O. mykiss* migration into the mainstem Guadalupe River, and other native fish populations, will increase. Future juvenile rearing monitoring will be used to evaluate this expectation.

3.2 Guadalupe Creek

Sampling occurred at six stations on the Guadalupe Creek on October 16, 17, and November 6, 2018. All sampling days were sunny and clear. Flows at the four stations upstream of Masson Dam on Guadalupe Creek (GR003 – GR006), based on ALERT Gage 5017 Guadalupe Creek below Guadalupe Reservoir, were 2.1 cfs. Flows at the two stations downstream of Masson Dam (GC001 and GC002), based on ALERT gage 5114 Masson Fish Ladder- Low Flow Only, were approximately 2.5 cfs.

GC001

This was the most downstream station sampled and had been sampled during the previous monitoring effort; during the data collection effort between 2004 and 2017, this station was known as Site 14. This sampling station is surrounded by urban residential housing and falls within a mitigation reach for the Downtown Project, where extensive geomorphic and riparian restoration occurred. The restoration was completed in 2002. The sampling station was 40 m in length with an average wetted width of 2.25 m and an average depth of 0.25 m. Two habitat types were present within the station: riffle and run (Figure 17). Each made up 50% of the sampled area. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 16.

.



Figure 17: Photos of station GC001, looking upstream (left) and looking downstream (right).

Table 16: Station GC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**		**Turbidity (NTU)**		
482	15.82	9.54		0.6		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	1	1	0	2	2	0

Three species of fish were captured during the survey: *O. mykiss,* prickly sculpin, and largemouth bass. The most abundant species encountered was prickly sculpin (n=21). One *O. mykiss* was captured and PIT tagged during the sampling effort (additional details on captured *O. mykiss* are provided in the Discussion section). Fish captured and associated population estimates are summarized in Table 17. The maximum likelihood iterations indicate that the number of largemouth bass is likely higher than what was captured.

Table 17: Number captured and population estimates at Station GC001 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	1	-	-	-
Prickly sculpin	Yes	21	21	0.849	21-23
Largemouth bass	No	5	6	3.572	5-15

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC001 has 13 years of comparable data. No data was collected in this reach in 2015 due to drought-induced drybacks. Figure 18 shows the standardized capture of *O. mykiss* between 2004 and 2018. In most years *O. mykiss* were captured at this station. The highest capture rate occurred in 2006 at 0.20 fish/meter. The average *O. mykiss* density at this site between 2004-2017 was 0.05 fish per meter. The density during the 2018 monitoring was 0.03 *O. mykiss* per meter. This was lower than the average from previous years' data collection effort. Results indicate that juvenile rearing in this portion

of Guadalupe Creek is variable, numbers were below average for this station in 2018, but recolonization did occur after the 2014 drought conditions and dry-backs of 2015.

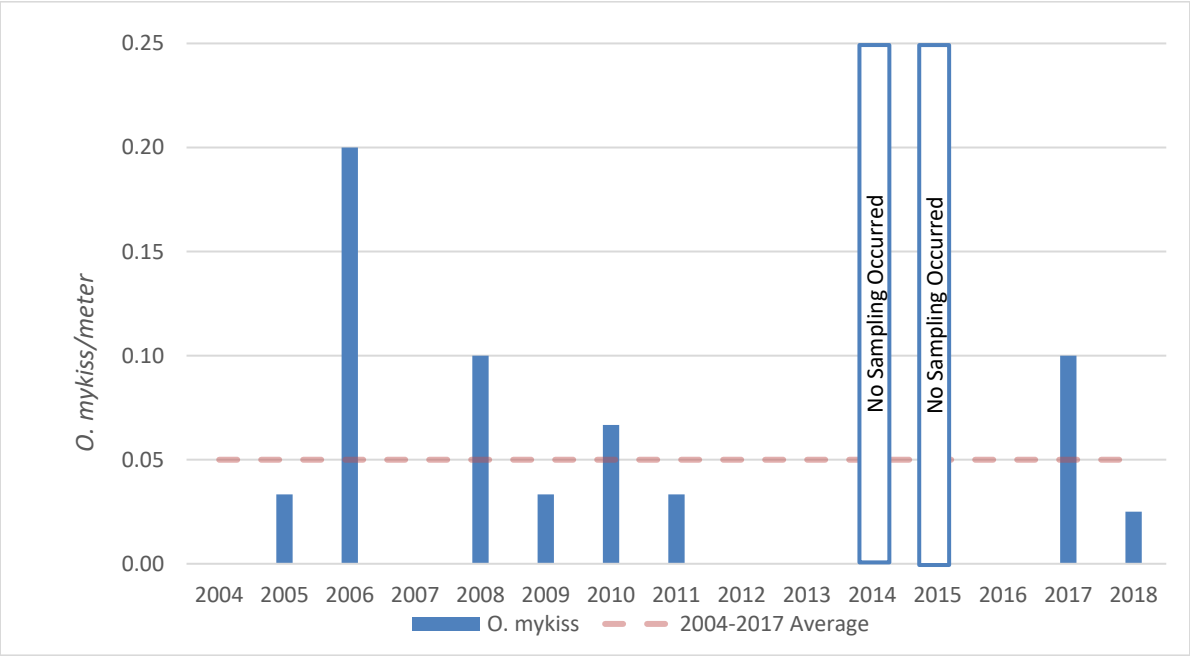


Figure 18: Station GC001 (previously Station 14) standardized *O. mykiss* capture 2004-2018.

GC002

This station was sampled during the previous monitoring effort; during the data collection effort between 2004 and 2017, this station was known as Site 16. The station is also within the mitigation reach for the Downtown Project. The sampling station was 40 m in length with an average wetted width of 4.0 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, glide, and run (Figure 19). The run habitat made up 35%, the riffle 40%, and the glide made up the remaining 25%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 18.



Figure 19: Photos of station GC002, looking upstream (left) and looking downstream (right).

Table 18: Station GC002 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
468	17.60	9.60	1.2

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	1	1	0	3	2	0

Four species of fish were captured during the survey: *O. mykiss*, prickly sculpin, riffle sculpin, and largemouth bass. The most abundant species encountered was prickly sculpin (n=12), and the maximum likelihood iteration indicated the population was likely higher than what was captured (N=14). Two *O. mykiss* were captured during the sampling effort and were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 19. American bullfrog (*Lithobates catesbeianus*) larvae were also collected in this reach.

Table 19: Number captured and population at Station GC002 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	2	2	0.384	2-7
Prickly sculpin	Yes	12	14	3.8	12-22
Riffle sculpin	Yes	9	9	0.461	9-10
Largemouth bass	No	4	4	0.969	4-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC002 has 13 years of comparable data. No data was collected in this reach in 2015 due to drought-induced drybacks. Figure 20 shows the standardized capture of *O. mykiss* between 2004 and 2018. In most years *O. mykiss* were captured at this station. The highest capture rate was 0.10 fish/meter, and occurred in years 2005, 2010, and 2017. The average *O. mykiss* density at this site between 2004-2017 was 0.04 fish per meter. The density during the 2018 monitoring was 0.05 *O. mykiss* per meter. Results indicate that juvenile rearing in this portion of Guadalupe Creek is variable, and 2018 had higher than average densities. This station was the only station to have detection of *O. mykiss* in 2016, and has continued to support these fish after the drought starting in 2014 and drybacks of 2015.

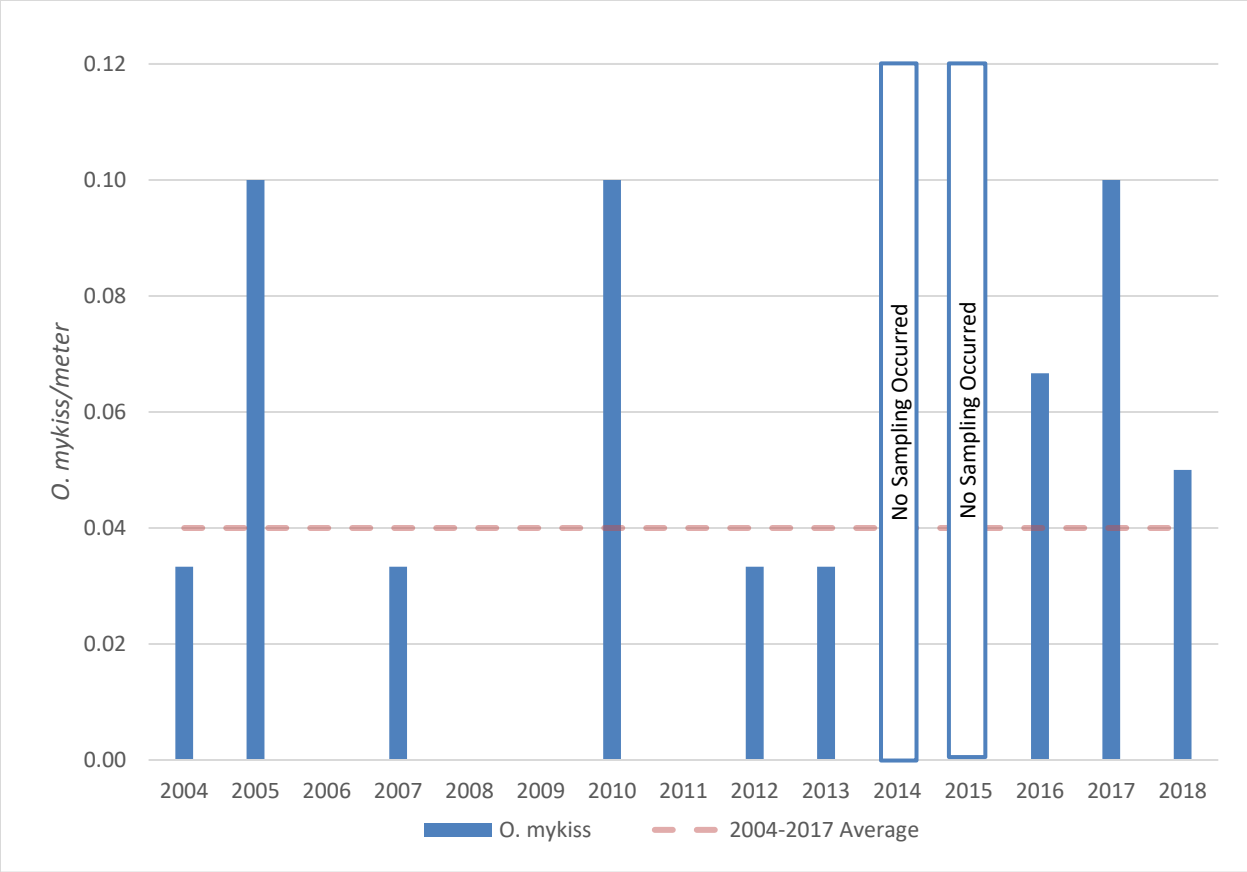


Figure 20: Station GC002 (previously Station 16) standardized *O. mykiss* capture 2004-2018.

GC003

This station was sampled during the previous monitoring effort; during the data collection effort between 2004 and 2017, this station was known as Site 18. The station is upstream of Masson Dam, and is in an urban residential area. The sampling station was 40 m in length with an average wetted width of 4.0 m and an average depth of 0.2 m. Three habitat types were present within the station: riffle, run, and pool (Figure 21). Habitat at the station was 48% riffle, 25% run, and 27% pool. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 20.



Figure 21: Photos of station GC003, looking upstream (left) and looking downstream (right).

Table 20: Station GC003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
445	13.07	9.70	13.0

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	1	1	0	3	1	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, riffle sculpin, and Sacramento sucker. The most abundant species encountered was riffle sculpin (n=58). Thirty-three *O. mykiss* were captured during the sampling effort, 30 of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 21.

In station GC003 the maximum likelihood iterations indicate that the number of California roach and *O. mykiss* is likely higher than what was captured. An estimate of 50 *O. mykiss* within the station was generated, but the standard error associated with the data is high. No non-native fish species were present in the reach.

Table 21: Numbered captured population estimates at Station GC003 on the Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	33	50	18.355	33-87
California roach	Yes	30	32	2.654	30-37
Riffle sculpin	Yes	58	58	1.058	58-60
Sacramento sucker	Yes	3	3	0.709	3-6

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC003 has 14 years of comparable data. Figure 22 shows the standardized capture of *O. mykiss* between 2004 and 2018. No sampling occurred in 2014 due to drought conditions. In all but four years, *O. mykiss* were captured at this station. This reach did not experience drybacks in 2015, but flow conditions were very low and no *O. mykiss* were captured in 2015 or 2016. In 2017 the fish returned, but in low density. The average *O. mykiss* density at this site between 2004-2017 was 0.10 fish per meter. The 2018 sampling resulted in the highest observed capture rate at 0.83 fish per meter and an estimated density of 1.25 *O. mykiss* per meter. This is one of the highest densities recorded during the 14-year monitoring period and was the highest observed capture rate for the entire Guadalupe River watershed 2018 monitoring effort. Results indicate that juvenile rearing in this portion of Guadalupe Creek is variable, and 2018 had much higher than average densities.

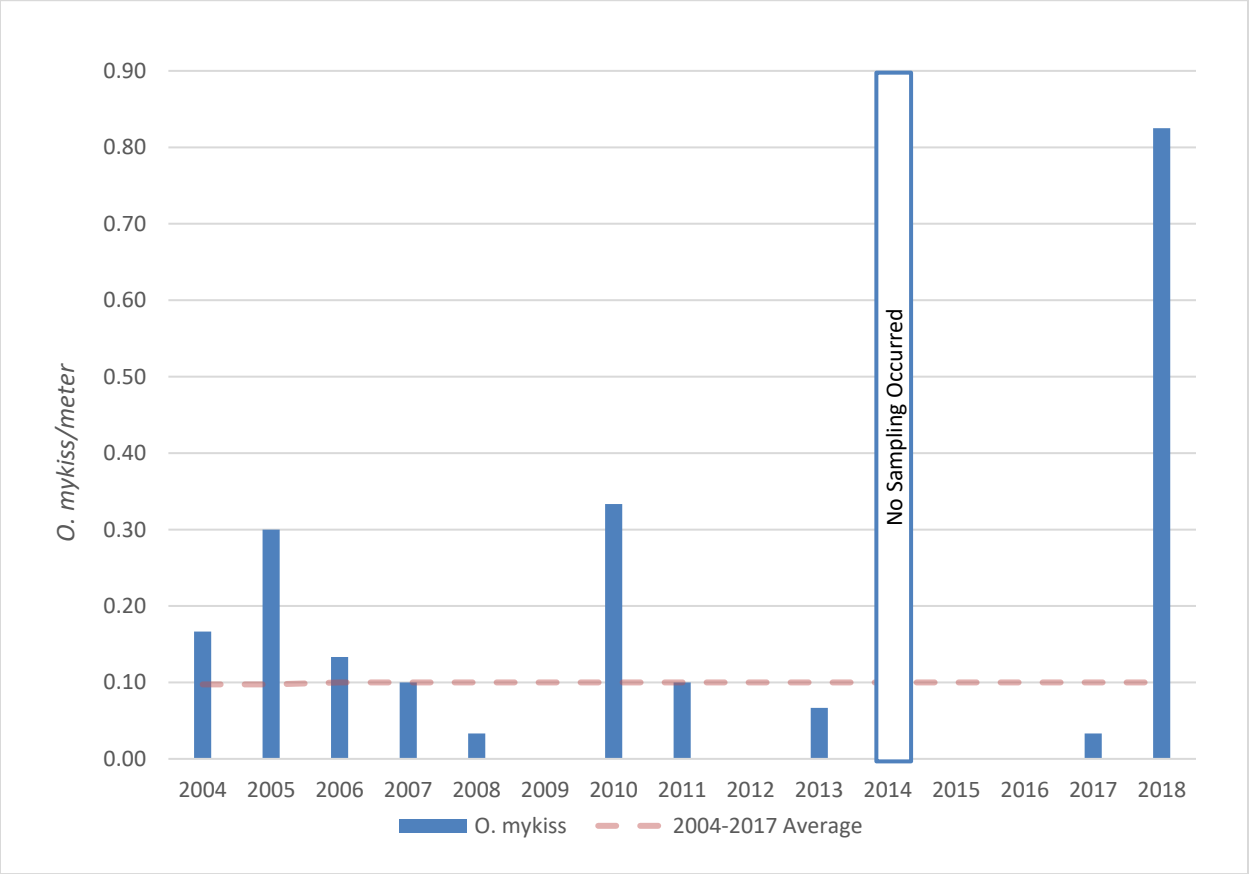


Figure 22: Station GC003 (previously Station 18) standardized *O. mykiss* capture 2004-2018.

GC004

This station was sampled during the previous monitoring effort; during the data collection effort between 2004 and 2017, this station was known as Site 20 and was the most upstream station sampled. The station is situated amongst rural residential areas. The sampling station was 40 m in length with an average wetted width of 6.0 m and an average depth of 0.15 m. Three habitat types were present within the station: riffle, run, and pool (Figure 23). Habitat at the station was 55% riffle, 28% run, and 28% pool. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 22.



Figure 23: Photos of station GC004, looking upstream (left) and looking downstream (right).

Table 22: Station GC004 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
402	16.49	10.87	11.2

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	3	1	2	3	2	0

Two species of fish were captured during the survey: *O. mykiss* and riffle sculpin. The most abundant species encountered was riffle sculpin (n=125). Eight *O. mykiss* were captured during the sampling effort, four of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 23.

Table 23: Number captured and population estimates at Station GC004 on the Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	8	8	0.512	8-9
Riffle sculpin	Yes	125	139	7.285	125-153

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC004 has 14 years of comparable data. Figure 24 shows the standardized capture of *O. mykiss* between 2004 and 2018. In all but three years, *O. mykiss* were captured at this station. This reach did not experience drybacks in 2015, but flow conditions were very low and no *O. mykiss* were captured in 2015 or 2016. In 2017 the fish returned. The highest density of *O. mykiss* occurred in 2005 at 1.03 fish per meter. This was the highest density recorded at any station during the entire 14-year monitoring period. The average *O. mykiss* density at this site between 2004-2017 was 0.45 fish per meter. The density during the 2018 monitoring was lower than the average from previous years data collection effort at 0.20 *O. mykiss* per meter, and this station has seen below average results during the last six sampling years. Though the densities are below average, the reach still appears to consistently support rearing, and recolonization occurred after the 2014 drought conditions.

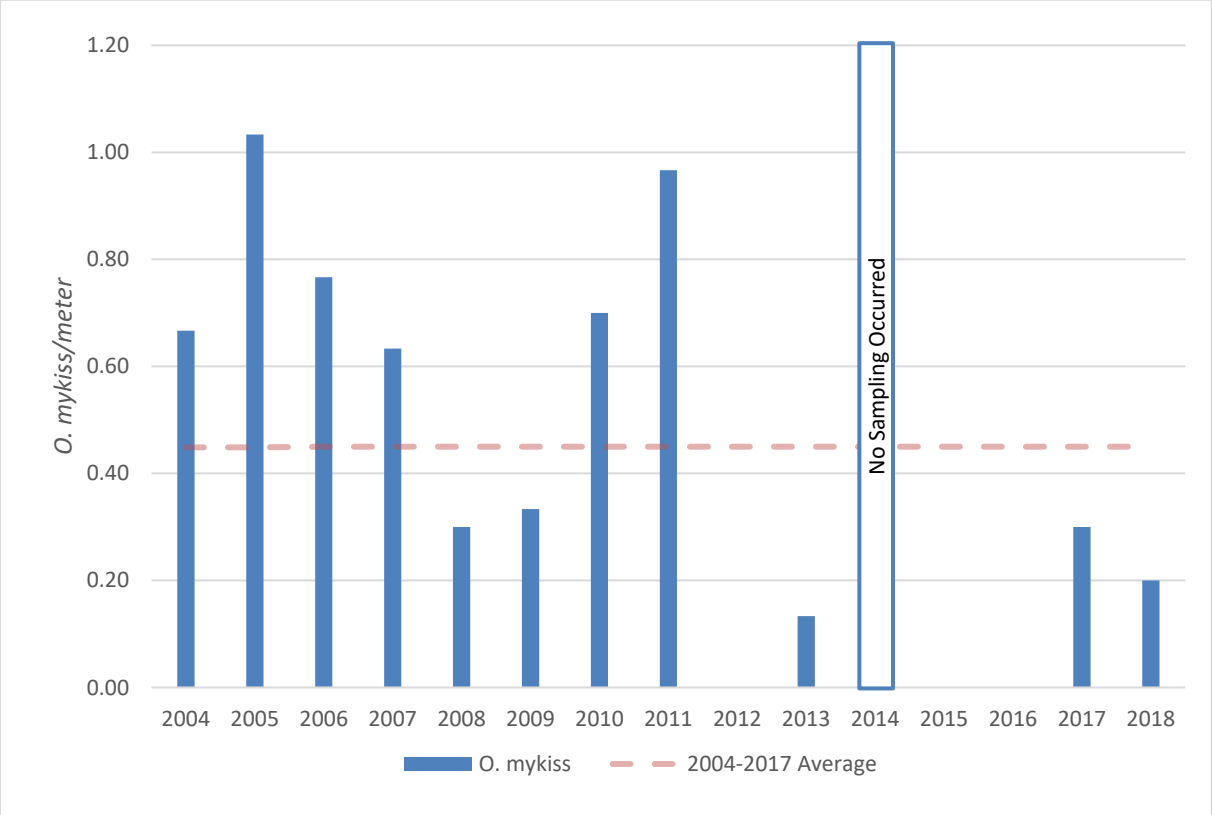


Figure 24: Station GC004 (previously Station 20) standardized *O. mykiss* capture 2004-2018.

GC005

This station was part of the expanded monitoring effort (WY 2018) and was selected randomly. The station is surrounded by limited residential housing, but land disturbance to the east is present. The sampling station was 40 m in length with an average wetted width of 3.0 m and an average depth of 0.2 m. Three habitat types were present within the station: riffle, run, and a side channel pool (Figure 25). The riffle habitat made up 55%, the run 45%, and the pool was in a small side channel surrounded by a riffle to run transition. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 24.



Figure 25: Photos of station GC005, looking upstream (left) and looking downstream (right).

Table 24: Station GC005 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
427	14.51	11.61	10.70			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	3	1	2	3	1	0

Two species of fish were captured during the survey: *O. mykiss* and riffle sculpin. The most abundant species encountered was riffle sculpin (n=73). Seventeen *O. mykiss* were captured during the sampling effort, 10 of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 25. In station GC005 the maximum likelihood iterations indicate that the number of both prickly sculpin and *O. mykiss* is likely higher than what was captured.

Table 25: Number captured and population estimates at Station GC005 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	17	20	4.464	17-29
Riffle sculpin	Yes	73	77	3.211	73-83

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Since this was the first year of sampling at this station no comparisons over time can be made, but the 2018 results for this station can be compared with the long-term average for Guadalupe Creek. This station had an observed density (based on n) of 0.43 *O. mykiss* per meter and an estimated density (based on N) of 0.50 *O. mykiss* per meter. The average *O. mykiss* density from the 2004-2017 sampling period for repeated Guadalupe Creek stations is 0.16 *O. mykiss* per meter. This station was above the long-term average for Guadalupe Creek and very similar to the average *O. mykiss* density of the closest repeated station—Station GC004 with 0.45 *O. mykiss* per meter.

GC006

This station was part of the expanded monitoring effort and was selected randomly. The station is surrounded by limited rural residential housing and was the most upstream station sampled. The sampling station was 40 m in length with an average wetted width of 3.5 m and an average depth of 0.2 m. Three habitat types were present within the station: riffle, run, and pool (Figure 26). The riffle habitat made up 58%, the run 25%, and the pool the remaining 17%. The primary substrate was cobble with a secondary

substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 26.



Figure 26: Photos of station GC006, looking upstream (left) and looking downstream (right).

Table 26: Station GC006 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
411	15.23	13.80	21.90			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	1	1	1	4	2	0

Three species of fish were captured during the survey: *O. mykiss*, riffle sculpin, and Sacramento sucker. The most abundant species encountered was riffle sculpin (n=22). Five *O. mykiss* were captured during the sampling effort, three of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 27. The maximum likelihood iterations did not provide a population estimate higher than what was observed. Sacramento sucker were encountered in this station, but not in the two stations downstream.

Table 27: Number captured and Population estimate at Station GC006 on the Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	5	5	0.444	5-6
Riffle sculpin	Yes	22	22	0.814	22-24
Sacramento sucker	Yes	3	3	0.709	3-6

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

As with Station GC005, this was the first year of sampling at this station so no comparisons over time can be made, but the 2018 results for this station can be compared with the long-term average for Guadalupe Creek. This station had an observed density (based on n) of 0.13 *O. mykiss* per meter. The average *O. mykiss* density from the 2004-2017 sampling period for repeated Guadalupe Creek stations is 0.16 *O. mykiss* per meter. This station is slightly below the long-term average for Guadalupe Creek, but still supported *O. mykiss*.

Discussion

Based on the results of the WY 2018 sampling, Guadalupe Creek continues to support rearing of *O. mykiss*. A total of 66 *O. mykiss* were collected in the six sampling stations. Fork-lengths ranged from 56 mm to 199 mm (Figure 27). Growth rates of juvenile *O. mykiss* in California are highly variable and are dependent on temperature, food availability, seasonal flow, and population densities/competition (Moyle 2002). According to Moyle (2002), in small streams with low summer flows, such as the Guadalupe Creek, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith and Leicester (2016) aged 32 fish from Guadalupe Creek and found that young-of-the-year *O. mykiss* ranged from 85–114 mm, and fish in their second year ranged from 110–195 mm. This is a faster growth rate than predicted by Moyle (2002), but this is expected in warmer, more productive systems. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, *O. mykiss* captured in Guadalupe Creek in WY 2018 were predominantly young-of-the-year, with some that had been through a second summer, and one fish that may have

been it its third year. The abundance of young-of-the-year fish observed indicates that Guadalupe Creek had successful reproduction and summer rearing in 2018.

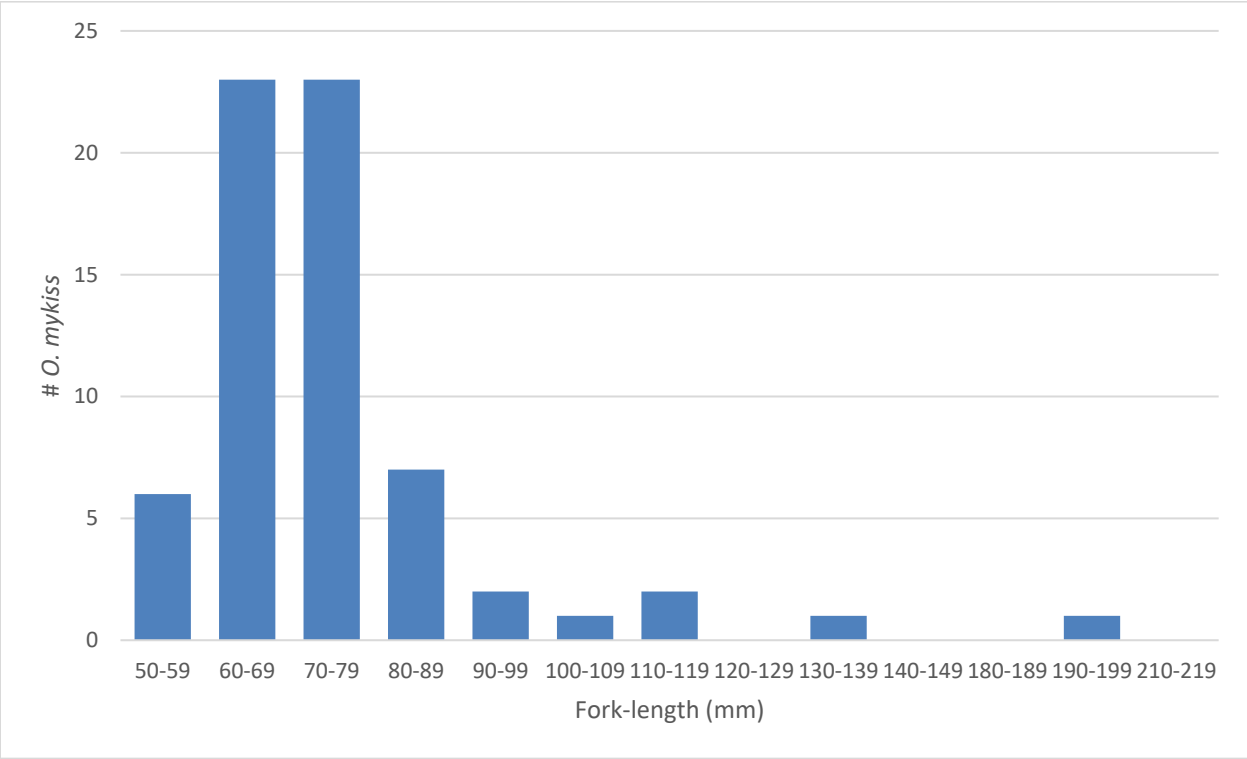


Figure 27: Guadalupe Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

The average *O. mykiss* density for all repeated sampling stations in 2018 was 0.28 fish per meter (based on the number of fish caught [n]). The average *O. mykiss* per meter for the repeated sampling stations between 2004-2017 was 0.16 fish. The number of *O. mykiss* observed in 2018 was higher than average. When the expanded sampling stations (GC005 and GC006) are included in the 2018 average, it maintains a 0.28 *O. mykiss* per meter average (based on n); therefore, expanding the sampling upstream of the previously sampled stations (WYs 2004-2017) did not impact the average. The maximum likelihood iteration indicates that it is likely that the number of *O. mykiss* present in Guadalupe Creek is higher than what was observed during our sampling effort (0.35 fish per meter based on N). Based on the density of *O. mykiss* at each

station, juvenile rearing appears to occur throughout Guadalupe Creek with no clear up- to downstream trend (Figure 28).

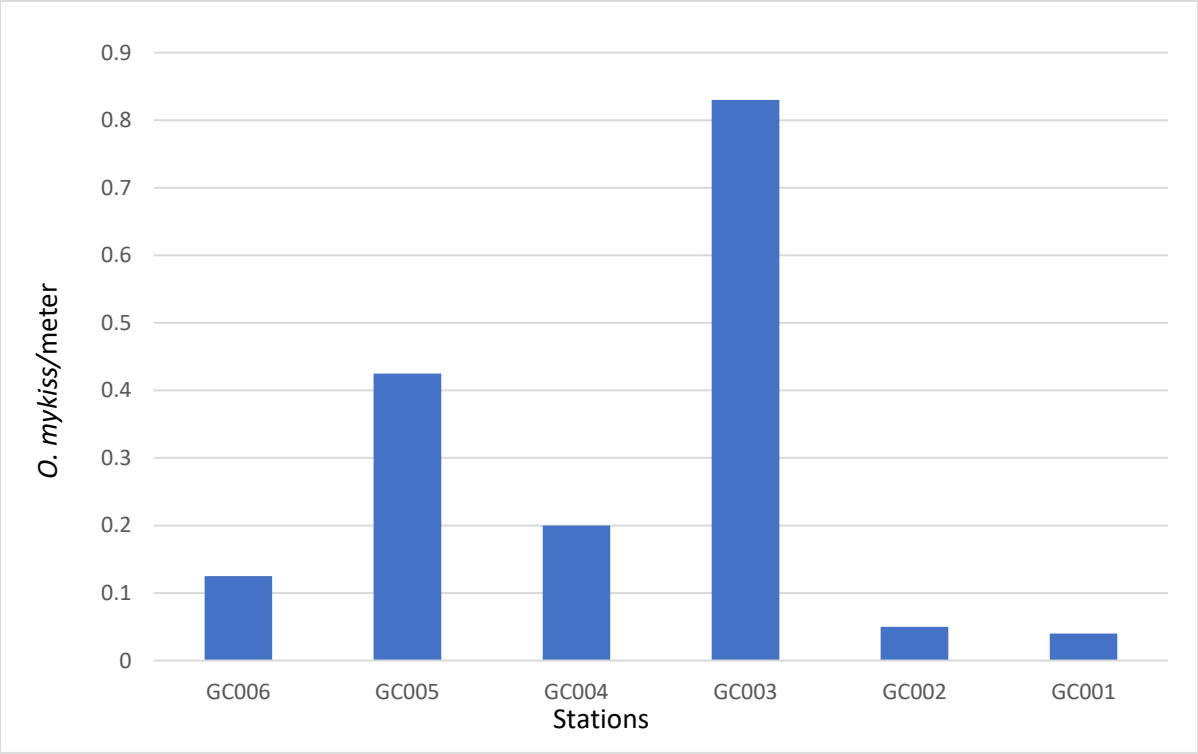


Figure 28: 2018 *O. mykiss* catch per unit effort oriented up- to downstream on Guadalupe Creek.

Guadalupe Creek supports four species of native fish, with multiple age classes of *O. mykiss,* and few non-native species. Of the 66 *O. mykiss* encountered during the sampling efforts, five had a Neascus-type parasitic infection commonly called “blackspot” disease. The visible black spots associated with fish are the metacercaria stage of the free-swimming parasite that produce a melanin-induced fibrous cyst (Schaaf et al. 2017). None of the fish observed were classified as a severe infection (raised cysts present on greater than 25% of the body). Most infected fish were recorded as minor with only a few raised cysts (Figure 29). The impacts to *O. mykiss* associated with this infection are not known.

When data from 2004-2017 is also considered, the results indicate that *O. mykiss* production is variable, and the species is resilient. After not collecting any *O. mykiss* in Guadalupe Creek in 2015 and only two in 2016, there has been a steady increase in total number of O. mykiss collected. Guadalupe Creek is clearly important for production of *O. mykiss* in the Guadalupe River watershed.

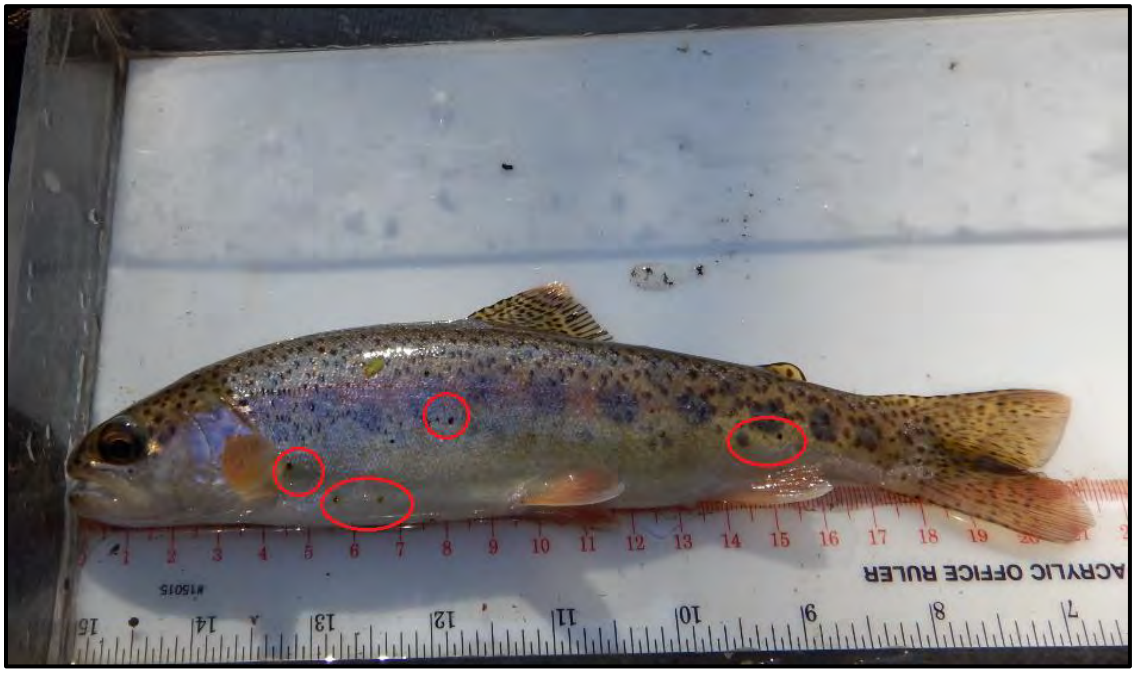


Figure 29: Guadalupe Creek *O. mykiss* with minor blackspot disease. Melanin induced cysts are circled in red.

3.3 Los Gatos Creek

Sampling occurred at four new stations on Los Gatos Creek on November 1 and 5, 2018; juvenile rearing monitoring had not been conducted previously in this system. All sampling days were sunny and clear. Flows on Los Gatos Creek, based on ALERT gage 5050 – Los Gatos Creek at Lincoln Avenue, were approximately 5.0 cfs.

LG001

This was the most downstream station sampled on Los Gatos Creek. The station is bordered by urban development and there were numerous homeless encampments and other signs of human disturbance during sampling. The sampling station was 40 m in

length with an average wetted width of 4.5 m and an average depth of 0.3 m. Two habitat types were present within the station: riffle and run (Figure 30). Each habitat type made up 50% of the area sampled. The primary substrate was gravel with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 28.

Two species of fish were captured during the survey: California roach and Sacramento sucker. The most abundant species encountered was California roach (n=78). No *O. mykiss* were captured. Fish captured and associated population estimates are summarized in Table 29.



Figure 30: Photos of station LG001, looking upstream (left) and looking downstream (right).

Table 28: Station LG001 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)
439	16.91	10.12	18.20

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	2	1	2	2	2	0

Table 29: Number captured and population estimates at Station LG001 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
California roach	Y	78	113	23.41	78-159
Sacramento sucker	Y	3	3	0	3-3

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station LG001 had high capture rates for California roach, and the population estimates indicates that the number of fish was likely higher. All fish captured at this station were native. The lack of non-native fish at this station is positive and the habitat that is present could potentially support rearing of *O. mykiss*.

LG002

The station is situated amongst urban residential areas. Large stands of non-native *Arundo donax* were present along the entire right bank and a sakrete wall lined portions of the left bank. The sampling station was 40 m in length with an average wetted width of 4.5 m and an average depth of 0.65 m. Three habitat types were present within the station: riffle, run, and pool (Figure 31). The riffle habitat made up 20%, the run made up 35%, and the pool made up the remaining 35%. The primary substrate was gravel with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 30.



Figure 31: Photos of station LG002, looking upstream (left) and looking downstream (right).

Table 30: Station LG002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
457	15.96	10.18	12.90			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	2	1	2	1	2	2

Three species of fish were captured: California roach, Sacramento sucker, and mosquitofish. The most abundant species encountered was California roach (n=43). No *O. mykiss* were captured. Fish captured and associated population estimates are summarized in Table 31.

Table 31: Number captured and population estimate at Station LG002 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
California roach	Y	43	46	3.249	43-53
Sacramento sucker	Y	27	27	0.925	27-29
Mosquitofish	N	4	6	0	4-6

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

There were high capture rates of native fish at Station LG002. The only non-native species captured was mosquitofish. The pool habitat in the downstream portion of this station is suitable for non-native predatory fish, so the absence of these species is positive.

LG003

The station is bordered by residential development. Trash and other impacts associated with homeless encampments and other human uses were prevalent in the area surrounding this station. The sampling station was 40 m in length with an average wetted width of 3.5 m and an average depth of 0.3 m. Three habitat types were present

within the station: riffle, run, and glide (Figure 32). The riffle habitat made up 28%, the run 65% and the glide the remaining 7%. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 32.



Figure 32: Photos of station LG003, looking upstream (left) and looking downstream (right).

Table 32: Station LG003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
448	16.63	10.73	13.40			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	3	1	2	2	2	0

Two species of fish were captured during the survey: prickly sculpin and Sacramento sucker. The most abundant species encountered was Sacramento sucker (n=15). No *O. mykiss* were captured. Fish captured and associated population estimates are summarized in Table 33. Station LG003 had lower capture rates for California roach and Sacramento sucker than the reaches downstream, but no non-native fish were

captured. The lack of non-native fish at this station is positive, and the habitat that is present could potentially support rearing of *O. mykiss*.

Table 33: Number captured and population estimates at Station LG003 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
Prickly sculpin	Y	2	2	0.384	2-7
Sacramento sucker	Y	16	17	1.997	16-21

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

LG004

This is the most upstream station and is situated amongst commercial development. The sampling station was 40 m in length with an average wetted width of 4.0 m and an average depth of 0.6 m. Two habitat types were present within the station: riffle and run (Figure 33). The riffle habitat made up 45% of the habitat and the run the remaining 55%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 34.

Five species of fish were captured during the survey: Sacramento sucker, common carp, goldfish (*Carassius auratus*), largemouth bass, and mosquitofish. The most abundant species encountered was Sacramento sucker (n=10) and it was the only native species observed at the station. No *O. mykiss* were captured at this sampling station. Fish captured and associated population estimates are summarized in Table 35.



Figure 33: Photos of station LG004, looking upstream (left) and looking downstream (right).

Table 34: Station LG004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
451	16.85	7.80		16.40		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	3	1	2	3	2	0

Table 35: Number captured and population estimates at Station LG004 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
Sacramento sucker	Y	10	14	8.151	10-32
Common carp	N	1	-	-	-
Goldfish	N	2	2	1.876	2-26
Largemouth bass	N	3	3	1.271	3-8
Mosquitofish	N	7	7	0.124	7-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Though the native Sacramento Sucker was the most abundant species, the overall species richness was 80% non-native. This station also supported goldfish and common carp, which were not seen at other sampling stations within the system.

Discussion

No *O. mykiss* were collected in Los Gatos Creek in WY 2018, although all stations had some suitable habitat complexity (i.e., undercut banks, large woody debris, or submerged roots) that could be used as refugia and had riffle habitat that should support fast-water feeding requirements. Since this was the first year of sampling on this creek, the historic densities are not known. *O. mykiss* are present in the system, at least periodically, as they have been observed by others. For example, Hobbs et al. (2014) sampled Los Gatos Creek in January and February 2014 and captured a total of nine *O. mykiss* at two stations, but captured none in October 2014 at a sampling station near Bascom Avenue (Hobbs et al. 2015). It is likely that *O. mykiss* production is not high in this system, and/or Los Gatos Creek could be subject to some of the same issues as the mainstem Guadalupe River, such as lack of population recovery from drought conditions. Additional juvenile rearing monitoring in future years will help evaluate this hypothesis.

Los Gatos Creek had a relatively low proportion of non-native species in the three downstream-most sampling reaches, and although the upstream-most reach had more non-native species, native fish were still more abundant. As with *O. mykiss* productivity, a better understanding of occurrence and trends of other native and non-native fish are expected to develop as additional juvenile rearing data is collected.

3.4 Alamitos Creek

Sampling occurred at four stations on Alamitos Creek on October 18 and 22, 2018. Most sampling days were overcast. Flows at the two upstream-most stations, based on ALERT gage 1544 Alamitos Creek below Almaden Reservoir, were approximately 2.6 cfs. Flows at the two downstream-most stations (AC001 and AC002), which are

downstream of the confluence with Calero Creek, were approximately 5.0 cfs, based on ALERT gage 5070 Alamitos Creek at Greystone.

AC001

This was the most downstream station sampled on Alamitos Creek. The station is situated in an urban residential area with a walking trail along the left bank. The sampling station was 40 m in length with an average wetted width of 4.5 m and an average depth of 0.2 m. Two habitat types were present within the station: riffle and run (Figure 34). The riffle habitat made up 55% of the habitat and the run the remaining 45%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 36.



Figure 34: Photos of station AC001, looking upstream (left) and looking downstream (right).

Table 36: Station AC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
483	16.89	9.63	13.50			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	1	1	2	1	2	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, and Sacramento sucker. The most abundant species encountered was California roach (n=193). Four *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 37. The maximum likelihood iterations provided population estimates higher than what was recorded for California roach and prickly sculpin. All fish species captured were native.

Table 37: Number captured and population at Station AC001 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Y	4	4	0.969	4-7
California roach	Y	193	219	10.534	193-240
Prickly sculpin	Y	31	38	7.29	31-53
Sacramento sucker	Y	22	22	1.114	22-24

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can be made. As more data is collected trends can begin to be evaluated.

AC002

The station is situated in an urban residential area with a walking trail along the right bank. The sampling station was 40 m in length with an average wetted width of 4.5 m and an average depth of 0.4 m. Three habitat types were present within the station:

riffle, run, and pool (Figure 35). The riffle habitat made up 40% of the habitat, the run 35%, and a pool the remaining 25%. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 38.



Figure 35: Photos of station AC002, looking upstream (left) and looking downstream (right).

Table 38: Station AC002 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
462	17.01	9.94	22.90

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	2	0	0	2	2	0

Five species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, Sacramento sucker, and tule perch (*Hysterocarpus traskii*). The most abundant species encountered was prickly sculpin (n=36). Ten *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 39.

Table 39: Number captured and population estimates at Station AC002 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	10	20	25.403	10-73
California roach	Yes	26	27	1.73	26-31
Prickly sculpin	Yes	30	32	2.828	30-38
Sacramento sucker	Yes	7	24	84.855	7-200
Tule perch[2]	No	1	-	-	-

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

At station AC002 the maximum likelihood iterations provided population estimates higher than what was observed for California roach, prickly sculpin, Sacramento sucker, and *O. mykiss*. A population estimate of 20 *O. mykiss* within the station was calculated, but the standard error is high. Tule perch are native to California and were historically observed in the Coyote Creek watershed in 1922 (Hubbs 1925). This species was thought to be extirpated in Santa Clara County until 1999 when a single specimen was captured in Coyote Creek (SCVWD 2015). Tule perch do not show up in the historic records in Guadalupe Watershed, but are now established in Calero Reservoir (Leal et al. 2017). It is assumed that the reservoir is the source for the population in Alamitos Creek. Though the species is regionally native, it was likely not present in the Guadalupe Watershed until introductions to Calero Reservoir.

Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected in this station trends will be able to be evaluated overtime.

AC003

The station is located upstream of the Calero Creek confluence and is situated in an urban residential area. The right bank through half of the station has large boulders that were placed by a previous bank protection project. The sampling station was 40 m in

[2] Tule perch are native to California and were observed in the Coyote Creek watershed in 1922 (Hubbs 1925). Though the species is regionally native, it was likely not historically present in the Guadalupe Watershed. For this analysis the species is considered non-native.

length with an average wetted width of 3.0 m and an average depth of 0.3 m. Four habitat types were present within the station: riffle, run, glide, and rapids (Figure 36). The riffle habitat only made up 0.2% of the habitat, but the rapids through the large boulders of the bank protection directly downstream contributed to 28%. The run habitat made up 1% with the glide contributing the remaining 70.8%. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 40.



Figure 36: Photos of station AC003, looking upstream (left) and looking downstream (right).

Table 40: Station AC003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
401	15.38	9.93	20.20

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	3	1	1	2	2	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, Sacramento sucker, and green sunfish. The most abundant species encountered was

California roach (n=156). Ten *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 41.

Table 41: Number captured and population estimates at Station AC003 on Alamitos Creek.

Species	Native	N	N	SE	95% CI
O. mykiss	Yes	10	12	4.152	10-21
California roach	Yes	156	226	32.81	156-291
Sacramento sucker	Yes	23	90	204.048	23-495
Green sunfish	No	2	2	1.038	2-15

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC003 the maximum likelihood iterations provided population estimates higher than what was recorded for California roach, Sacramento sucker, and *O. mykiss*. This was the first station where non-native green sunfish were observed, but the density was the lowest out of all fish species captured. Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected in this station trends will be able to be evaluated overtime.

AC004

AC004 is the most upstream station on Alamitos Creek. Portions of the station were underneath the bridge that connects Almaden and Bertram Roads. The bridge footing extended into the channel. The sampling station was 40 m in length with an average wetted width of 5.0 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and glide (Figure 37). The riffle habitat made up 50% of the habitat, the run 15%, and the glide contributed the remaining 35%. The primary substrate was boulders with a secondary substrate of cobbles. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 42.



Figure 37: Photos of station AC004, looking upstream (left) and looking downstream (right).

Table 42: Station AC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
390	16.50	10.87		14.0		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	4	1	2	3	2	1

Three species of fish were captured during the survey: *O. mykiss,* California roach, and prickly sculpin. *O. mykiss* were the most abundant species present and of the eight captured, six were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 43.

Table 43: Number captured and population estimates at Station AC004 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	8	9	2.612	8-15
California roach	Yes	7	8	2.993	7-15
Prickly sculpin	Yes	2	2	0	2-2

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC004 the maximum likelihood iterations provided population estimate higher than what was recorded for California roach and *O. mykiss*. All fish species captured were native. Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected at this station trends will be able to be evaluated overtime.

Discussion

A total of 32 *O. mykiss* were collected in the four Alamitos Creek sampling stations. Fork-lengths ranged from 60 mm to 345 mm (Figure 38). Based on Moyle (2002) and Smith and Leicester (2016) growth rates, approximately half of the *O. mykiss* captured in WY 2018 were young-of-the-year and the other half have been through their second summer. One large, presumably resident rainbow trout measuring 345 mm was also captured. This size suggests the fish was at the end of its fourth year (Moyle 2002). Based on the results of the WY 2018 sampling, Alamitos Creek had successful reproduction and appears to support rearing of *O. mykiss* throughout its length (Figure 39). Alamitos Creek had successful reproduction and summer rearing in 2018. The *O. mykiss* in this system also showed signs of blackspot disease. Of the 31 captured, 15 had visible symptoms, with one being recorded as severe (Figure 40). Of all systems sampled, blackspot disease was most prevalent in Alamitos Creek *O. mykiss*.

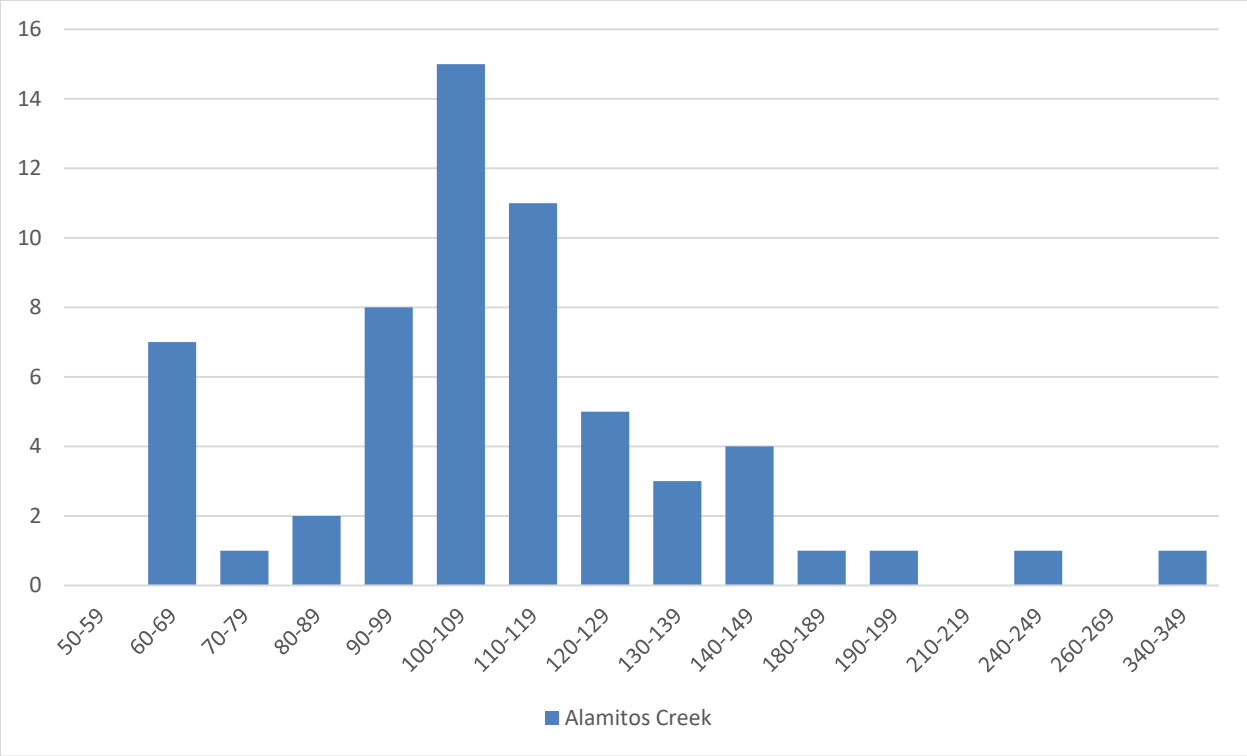


Figure 38: Alamitos Creek O. mykiss length histogram. All measurements are in fork-length and binned in 10 mm increments.

The average catch of *O. mykiss* in Alamitos Creek in 2018 was 0.20 fish per meter (Figure 39). When compared to the average standardized catch at repeated sampling stations between 2004-2018 on Guadalupe Creek (0.17 *O. mykiss* per meter) it is above average. During a fish relocation for a habitat improvement project approximately 500 m downstream of station AC001, SCVWD's Stream Maintenance Program (SMP) staff documented a density of 0.53 *O. mykiss* per meter (64 total fish). This was higher than the densities at any of the sampling stations. This sampling also led to the ability to PIT tag an additional 26 fish in the Alamitos Creek sub-watershed. The sizes and tag number of these fish can be seen in Appendix A.

Alamitos Creek is also supporting four other species of native fish, has a small population of tule perch that were once thought to be extirpated in Santa Clara County, and has relatively few non-native species. Non-native fish (including tule perch) made up less than 1% of the total number captured.

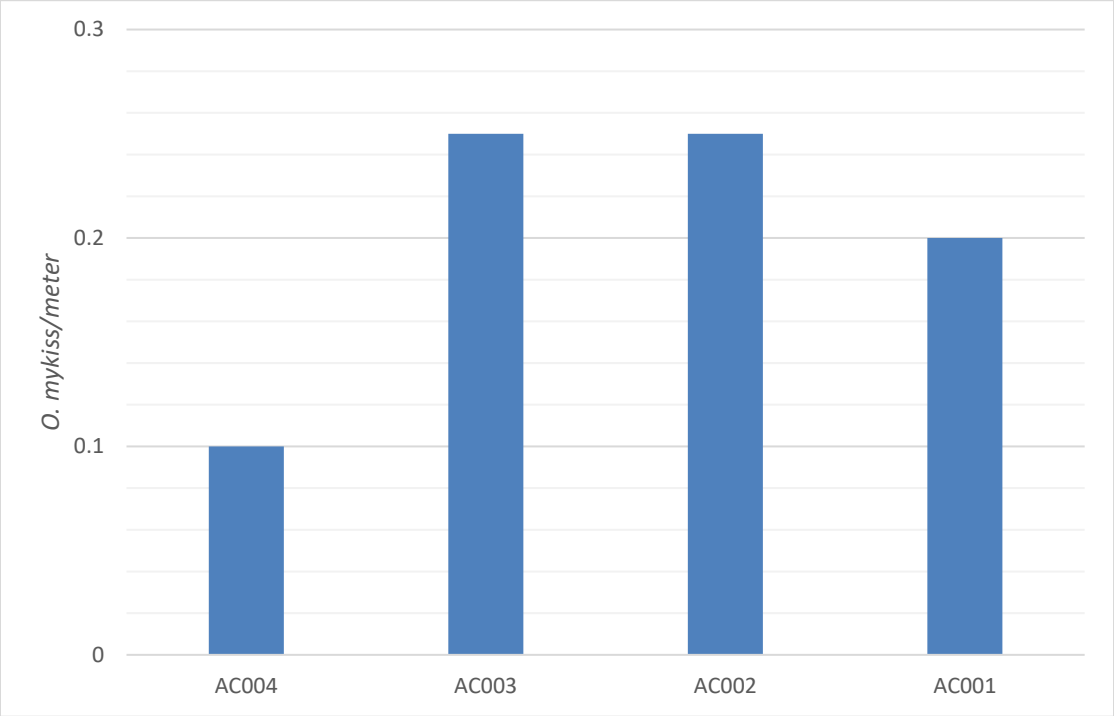


Figure 39: *O. mykiss* catch per unit effort oriented up- to downstream on Alamitos Creek.



Figure 40: Alamitos Creek *O. mykiss* with visible signs of blackspot disease (left being severe and right being minor).

3.5 Calero Creek

Sampling occurred at three stations on Calero Creek on October 23 and 24, 2018. The sampling days were a mix of overcast and clear. Flows on Calero Creek based on ALERT gage 5013 Calero Creek below Calero Reservoir were approximately 6.0 cfs.

CC001

This was the most downstream station sampled on Calero Creek. The station is situated in urban residential and was approximately 300 m upstream of the confluence with Alamitos Creek. The sampling station was 40 m in length with an average wetted width of 3.5 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and pool (Figure 41). The riffle habitat made up 53% of the habitat, the run 35%, and the pool the remaining 12%. A small side channel pool was present but lacked connectivity to the main channel. The primary substrate was gravel with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 44.



Figure 41: Photos of station CC001, looking upstream (left) and looking downstream (right).

Table 44: Station CC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
547	16.30	8.96		25.0		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	1	1	2	2	2	0

Five species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, Sacramento sucker, and tule perch. The most abundant species encountered was California roach (n=10). Four *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 45.

Table 45: Number captured and population estimate at Station CC001 on Calero Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	4	4	0.205	4-5
California roach	Yes	10	14	8.151	10-32
Largemouth bass	No	1	-	-	-
Prickly sculpin	Yes	5	5	0.787	5-7
Sacramento sucker	Yes	8	8	0.11	8-8
Tule perch	No	2	2	0.384	2-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC001 the maximum likelihood iterations provided population estimate higher than what was recorded for California roach. Non-native predatory largemouth bass were observed, but the density was the lowest out all fish species captured. As in Alamitos Creek, tule perch were captured but in low densities. Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected in this station trends will be able to be evaluated.

CC002

The station is situated in an urban residential area. A small sakrete structure at an outfall was present. The sampling station was 40 m in length with an average wetted width of 3.0 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and pool (Figure 42). The riffle habitat made up 42% of the habitat, the run 35%, and a pool the remaining 23%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 46.



Figure 42: Photos of station CC002, looking upstream (left) and looking downstream (right).

Table 46: Station CC002 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
477	16.33	8.78	38.0

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
0	2	1	2	3	2	1

Three species of fish were captured during the survey: *O. mykiss*, California roach, and Sacramento sucker. The most abundant species encountered was California roach (n=21). Four *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 47.

Table 47: Number captured and population estimates at Station CC002 on Calero Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	4	8	17.588	4-50
California roach	Yes	21	29	10.533	21-51
Sacramento sucker	Yes	6	6	1.002	6-9

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC002 the maximum likelihood iterations provided population estimates higher than what was recorded for California roach and *O. mykiss*. All fish species captured were native. Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected in this station trends will be able to be evaluated.

CC003

The station is situated in a rural/agricultural area. The sampling station was 40 m in length with an average wetted width of 3.5 m and an average depth of 0.25 m. Two habitat types were present within the station: riffle and glide (Figure 43). The riffle habitat made up 45% of the habitat with the glide making up the remaining 55%. The primary substrate was silt with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 48. Equipment failure limited the ability to collect DO and turbidity measurements.



Figure 43: Photos of station CC001, looking upstream (left) and looking downstream (right).

Table 48: Station CC003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
489	14.0	-		-		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	0	1	1	3	2	0

Three species of fish were captured during the survey: *O. mykiss,* California roach, and Sacramento sucker. The most abundant species encountered was Sacramento sucker (n=20). Nine *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 49.

Table 49: Number captured and population estimates at Station CC002 on Calero Creek.

Species	Native	N	N	SE	95% CI
O. mykiss	Yes	9	16	17.311	9-53
California roach	Yes	14	20	10.039	14-41
Sacramento sucker	Yes	20	24	5.268	20-35

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC003 the maximum likelihood iterations provided population estimates higher than what was recorded for all fish species. All species captured were native. Since this was the first year of sampling within this station, no direct comparisons of densities of *O. mykiss* over time can occur. As more data is collected in this station trends will be able to be evaluated.

Discussion

A total of 17 *O. mykiss* were collected in three sampling stations. Fork-lengths ranged from 67 mm to 263 mm (Figure 44). Based on Moyle (2002) growth rates, *O. mykiss* captured in Calero Creek in 2018 were mostly young-of-the-year, but some may have been in their second year. Based on Smith and Leicester (2016) growth rates, nearly all *O. mykiss* captured in 2018 were young-of-the-year. There were two fish collected that were in their third year (Moyle 2002). Calero Creek is supporting multiple age classes of *O. mykiss* and rearing appears to be distributed throughout the system, although higher densities were observed at the most upstream station (Figure 45). Based on the results of the WY 2018 sampling, Calero Creek supports rearing of *O. mykiss,* and had successful reproduction and summer rearing in 2018.

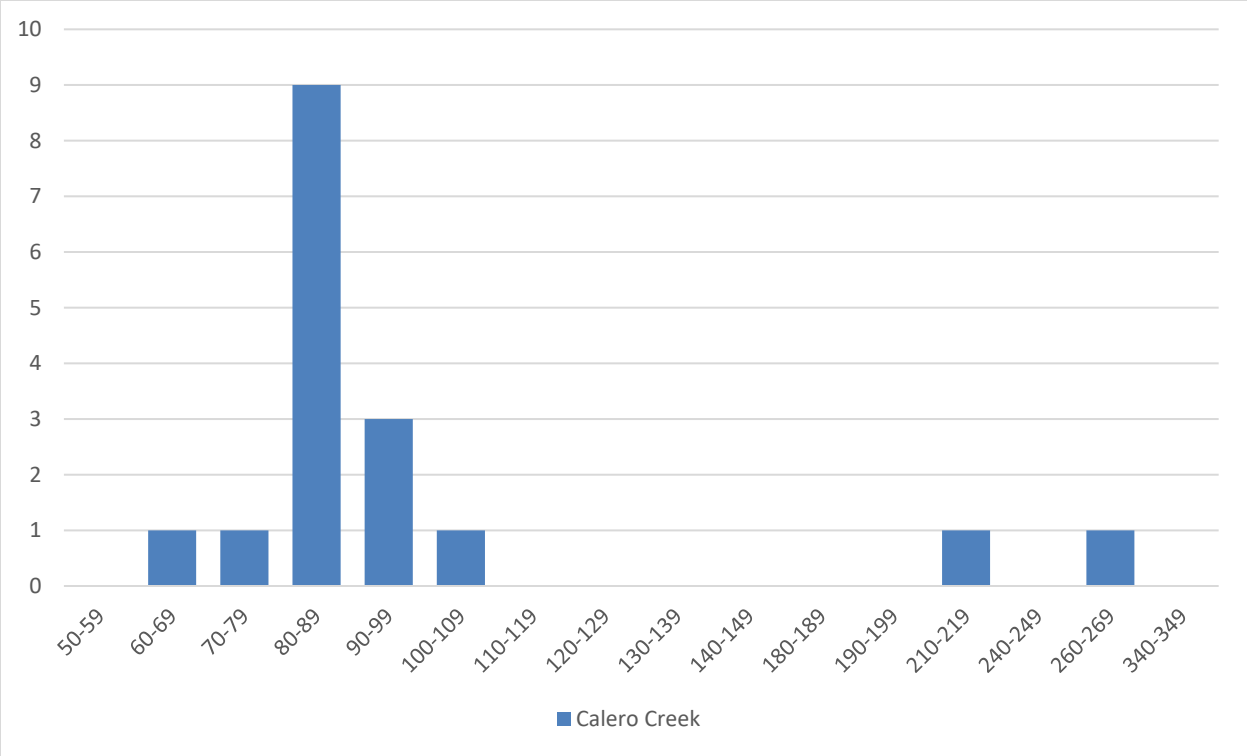


Figure 44: Calero Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

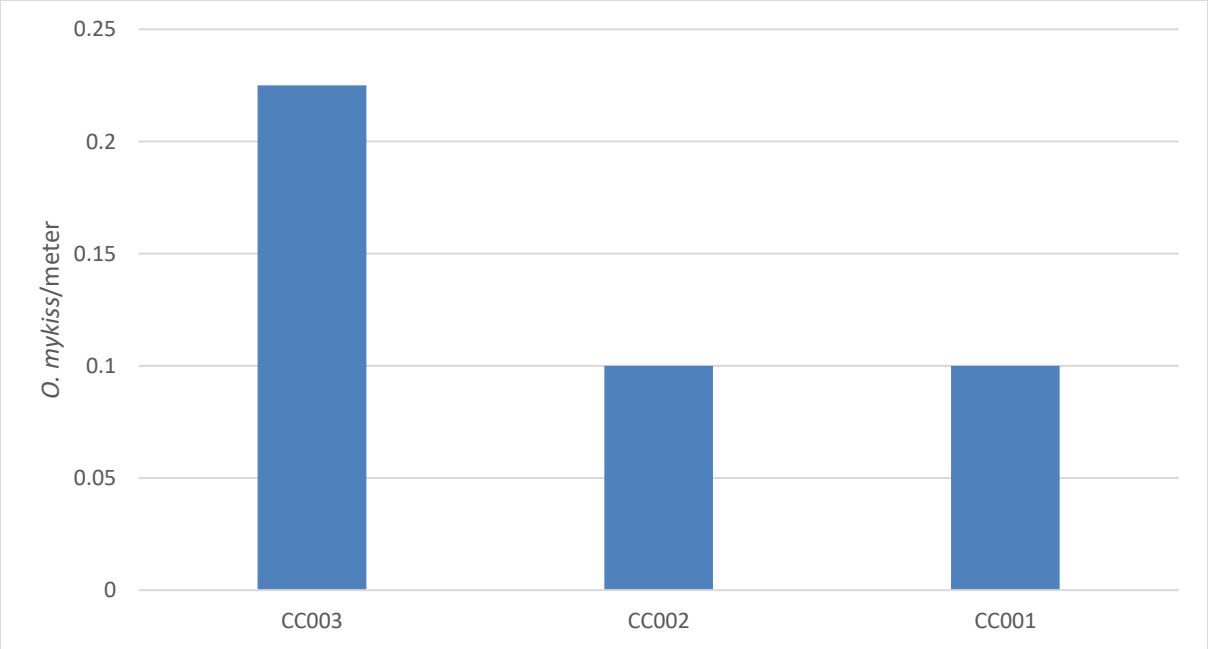


Figure 45: *O. mykiss* catch per unit effort oriented up- to downstream on Calero Creek.

The average catch of *O. mykiss* on Calero Creek in 2018 was 0.14 fish per meter. This is lower than the long-term average catch at repeated sampling stations on Guadalupe Creek (0.17 *O. mykiss* per meter) and Alamitos Creek (0.20 *O. mykiss* per meter). Guadalupe and Alamitos creeks are larger sub-watersheds, so it is expected that they would support higher fish densities. Although Calero Creek had a lower rearing density than Guadalupe Creek and Alamitos Creek, it still had a structured *O. mykiss* population and is contributing the overall production in the system. No blackspot disease was observed on *O. mykiss* in Calero Creek (Figure 46).



Figure 46: *O. mykiss* captured on Calero Creek.

4. Conclusion

In WY2018, juvenile *O. mykiss* were observed in Guadalupe, Alamitos, and Calero Creeks. They were not observed in the Guadalupe River or Los Gatos Creek. Based on historic data, it is not uncommon to not detect *O. mykiss* in the Guadalupe River at all sampling stations, as the occurrence data from 2004-2017 has always been sporadic. However, this is the longest duration (four years) where an *O. mykiss* has not been captured on the Guadalupe River during this monitoring. It is unknown if it is normal for

no detections to occur in Los Gatos Creek in some years, as this is the first year of sampling this creek. It is important to remember that electrofishing sampling only allows for specific habitats to be sampled. It is not feasible in deep pools, which may be the preferred habitat for *O. mykiss* inhabiting these two systems.

The average densities (fish per meter) and average length of *O. mykiss* detected in Guadalupe, Alamitos, and Calero Creeks can be seen in Table 50. Guadalupe Creek had the highest densities and a smaller average length. The average lengths of *O. mykiss* in Calero and Alamitos Creeks are slightly skewed by the presence of a few larger fish (likely residents), but when the distribution of size is seen in Figure 47 it shows that fish in the young of the year size range are still larger. Based on the size range of fish collected, production and successful summer rearing occurred and multiple age classes were present in the Guadalupe Watershed in 2018.

Table 50: 2018 average density and length of O. mykiss captured within Guadalupe, Alamitos, and Calero Creeks.

Sub-Watershed	*O. mykiss*/meter	Average length
Guadalupe Creek	0.275	75.8
Calero Creek	0.142	104.2
Alamitos Creek	0.200	105.3

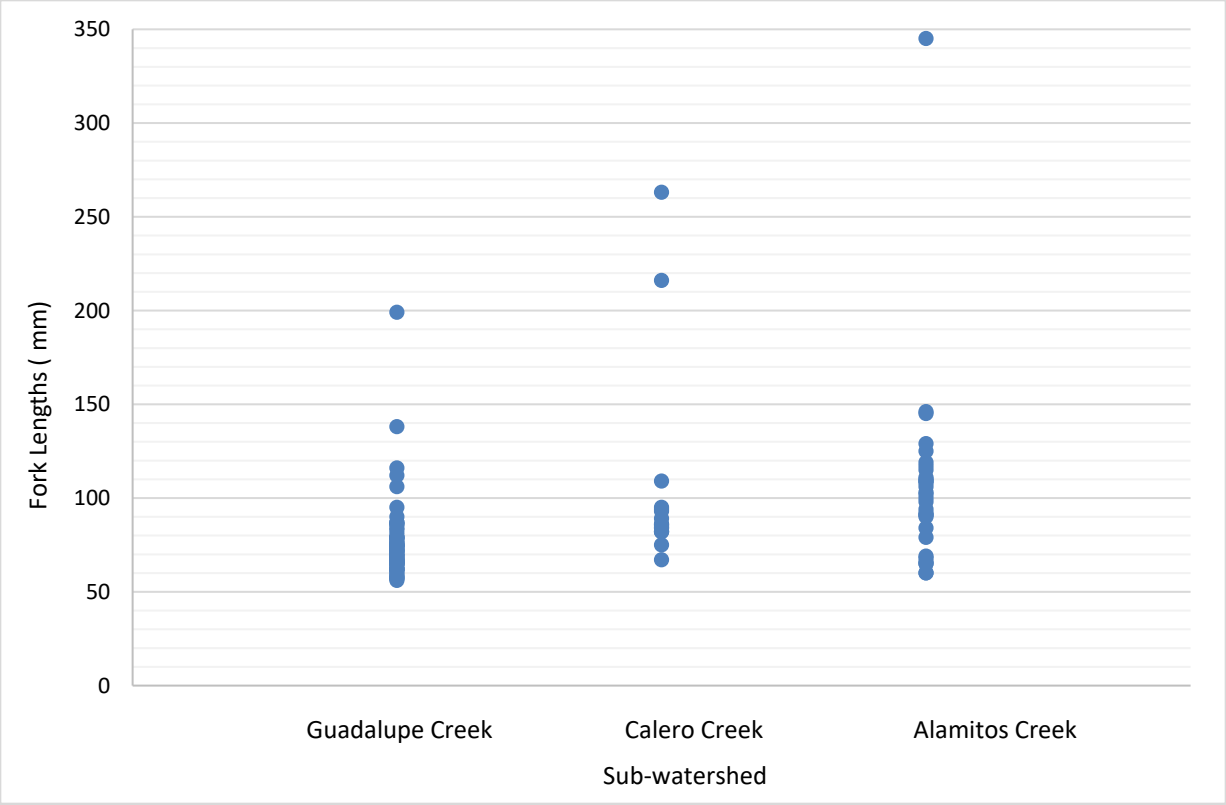


Figure 47*: O. mykiss* size distribution (fork length) for Guadalupe, Calero, and Alamitos Creek sub-watersheds.

In addition to *O. mykiss* data, information on the presence of non-native fish species in the Guadalupe Watershed was obtained. A total of seven different species not native to the Guadalupe Watershed were observed: largemouth bass, green sunfish, common carp, goldfish, mosquitofish, Chinook salmon, and tule perch. Of these seven species, only largemouth bass is considered a major predator of juvenile *O. mykiss,* though all others can impact the habitat and natural communities within the system. Los Gatos Creek and the Guadalupe River had the highest percentage of non-native species detected, with the number approaching 10% of captured fish. Guadalupe Creek, Alamitos Creek, and Calero Creek had a low percentage of non-natives, with less than 3% of captured fish being non-native in each of these sub-watersheds. Looking at the Guadalupe Watershed as a whole, the overall percentage of non-native fish is less than 4% of all fish observed (Table 51).

Table 51: Total capture of fish per sub-watershed and percentage of total capture that was non-native species.

Sub-watershed	Guadalupe River	Guadalupe Creek	Los Gatos Creek	Alamitos Creek	Calero Creek	Guadalupe Watershed
Total Fish Captured	194	451	197	542	104	1488
Percent Non-native	9.8%	2.0%	9.1%	0.6%	2.9%	3.5%

Juvenile *O. mykiss* are persisting in the Guadalupe Watershed, with multiple age classes present, and in Guadalupe Creek at levels that would be considered above average. Non-native fish are contributing to a small percentage of the total abundance, with Alamitos Creek having the lowest levels at less than 1.0% non-native species. Since this is the first year of expanded monitoring it is difficult to assess any trends at this time, but as more data become available a better understanding of the Guadalupe Watershed will develop.

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Appendix A

Santa Clara Valley Water District

Water Year 2018 *Oncorhynchus mykiss* Tagging Metadata

in the Guadalupe River Watershed

Site:	Time Start	Time End	Crew	Temp	Conductivity	FISH ID	Species	Weight (g)	Length (mm)	PIT ID (Decimal)	Genetics (Y/N)	Scales (Y/N)	Tagger	Fish Condition/Comments
GC006	9:15	10:45	JW,LL, JN, CL, CG, SG	15.23	411	2018GCRK001	O. mykiss	3.53	60	NA	y	N	NA	
GC006	9:15	10:45	JW,LL, JN, CL, CG, SG	15.23	411	2018GCRK002	O. mykiss	7.81	83	900.226000319227	y	N	LL	
GC006	9:15	10:45	JW,LL, JN, CL, CG, SG	15.23	411	2018GCRK003	O. mykiss	9.25	87	900.226000319276	y	N	LL	
GC006	9:15	10:45	JW,LL, JN, CL, CG, SG	15.23	411	2018GCRK004	O. mykiss	14.28	106	900.226000319293	y	N	LL	
GC006	9:15	10:45	JW,LL, JN, CL, CG, SG	14.51	411	2018GCRK005	O. mykiss	2.35	58	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK006	O. mykiss	4.75	67	900.226000319318	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK007	O. mykiss	4.62	72	900.226000319305	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK008	O. mykiss	4.01	65	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK009	O. mykiss	3.72	66	900.226000319334	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK010	O. mykiss	3.76	63	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK011	O. mykiss	6.37	72	900.226000319341	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK012	O. mykiss	3.58	65	900.226000319308	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK013	O. mykiss	31.33	138	900.226000319389	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK014	O. mykiss	6.82	81	900.226000319385	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK015	O. mykiss	4.58	66	900.226000319338	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK016	O. mykiss	4.45	64	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK017	O. mykiss	3.42	57	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK018	O. mykiss	3.09	56	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK019	O. mykiss	5.32	74	900.226000319324	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK020	O. mykiss	3.84	62	NA	y	N	NA	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK021	O. mykiss	6.93	86	900.226000319364	y	N	LL	
GC005	11:33	13:00	JW,LL, JN, CL, CG, SG	14.51	427	2018GCRK022	O. mykiss	5.32	72	NA	y	N	NA	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK023	O. mykiss	3.93	62	NA	y	N	NA	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK024	O. mykiss	6.66	79	900.226000319345	y	N	LL	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK025	O. mykiss	3.08	57	NA	y	N	NA	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK026	O. mykiss	3.53	58	NA	y	N	NA	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK027	O. mykiss	8.33	84	900.226000319358	y	N	LL	scarred
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK028	O. mykiss	6.12	76	900.226000319329	y	N	LL	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK029	O. mykiss	4.97	70	900.226000319351	y	N	LL	
GC004	13:30	15:50	JW,LL, JN, CL, CG, SG	16.49	402	2018GCRK030	O. mykiss	3.28	59	NA	y	N	NA	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK031	O. mykiss	3.23	61	NA	y	N	NA	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK032	O. mykiss	5.62	75	900.226000319346	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK033	O. mykiss	3.82	62	NA	Y	N	NA	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK034	O. mykiss	4.22	66	900.226000319394	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK035	O. mykiss	6.02	79	900.226000319386	Y	N	LL	minor blackspot
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK036	O. mykiss	4.36	62	NA	Y	N	NA	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK037	O. mykiss	5.9	77	900.226000319340	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK038	O. mykiss	4.52	70	900.226000319317	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK039	O. mykiss	5.14	72	900.226000319337	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK040	O. mykiss	8.05	86	900.226000319344	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK041	O. mykiss	4.23	68	900.226000319330	Y	N	LL	minor blackspot
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK042	O. mykiss	6.06	75	900.226000319307	Y	N	JW	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK043	O. mykiss	4.08	67	900.226000319309	Y	N	JW	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK044	O. mykiss	3.83	65	900.226000319333	Y	N	LL	

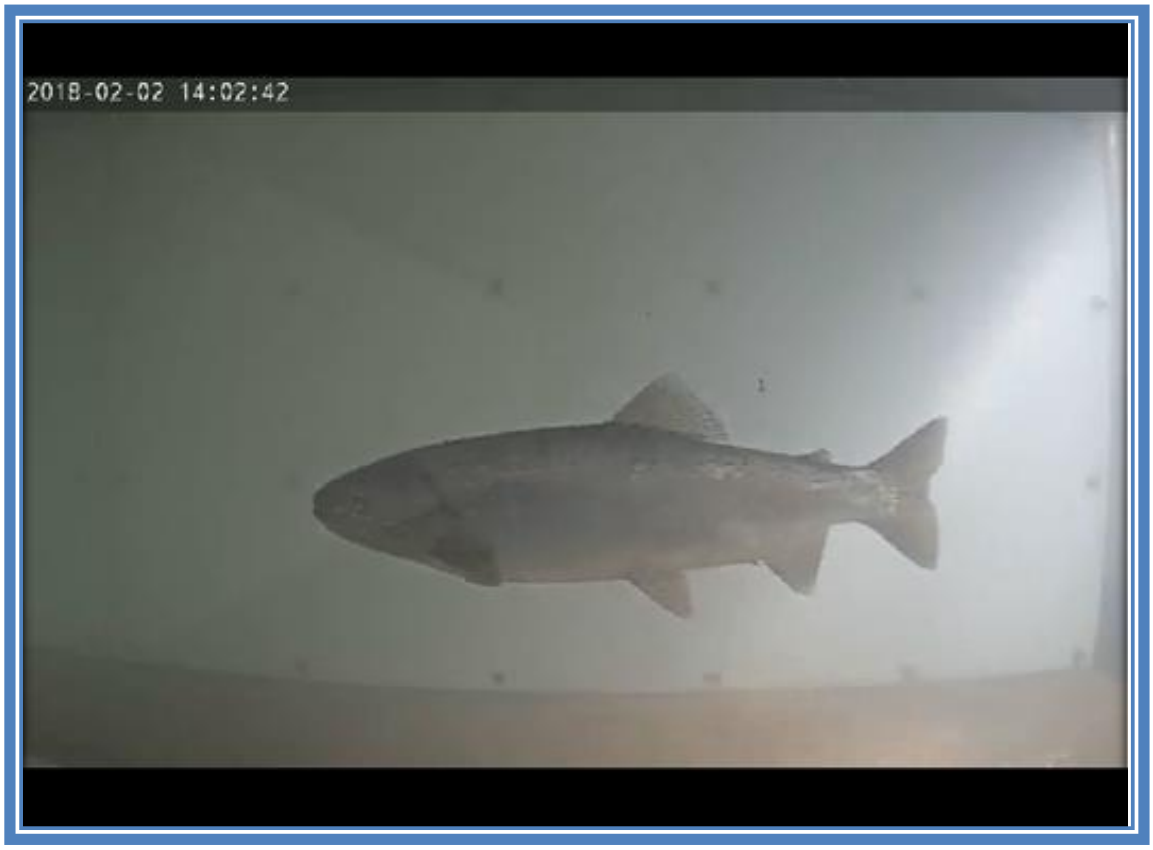
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK045	O. mykiss	5.66	74	900.226000319361	Y	N	LL	bleeder
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK046	O. mykiss	96.04	199	900.228000613702	Y	N	LL	minor blackspot
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK047	O. mykiss	4.61	65	900.226000319381	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK048	O. mykiss	6.62	76	900.226000319342	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK049	O. mykiss	4.35	66	900.226000319399	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK050	O. mykiss	4.63	70	900.226000319377	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK051	O. mykiss	5.68	72	900.226000319371	Y	N	LL	black spot
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK052	O. mykiss	6.23	75	900.226000319395	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK053	O. mykiss	4.95	69	900.226000319325	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK054	O. mykiss	6.2	78	900.226000319356	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK055	O. mykiss	6.22	79	900.226000319374	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK056	O. mykiss	4.36	69	900.226000319379	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK057	O. mykiss	4.53	67	900.226000319354	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK058	O. mykiss	18.15	112	900.226000319328	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK059	O. mykiss	3.85	68	900.226000319393	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK060	O. mykiss	5.05	79	900.226000319327	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK061	O. mykiss	5.23	74	900.226000319362	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK062	O. mykiss	11.22	90	900.226000319304	Y	N	LL	
GC003	9:50	12:19	JW,LL, JN, CL, CG	13.07	445	2018GCRK063	O. mykiss	5.31	74	900.226000319398	Y	N	LL	1 blackspot
GC001	8:19 AM	9:30	CL, JW, SG, LL	15.82	482	2018GCRK064	O. mykiss	12.4	95	900.226000319294	Y	N	JW	
GC002	9:45 AM	10:30	CL, JW, SG, LL	17.6	482	2018GCRK065	O. mykiss	8.7	87	900.226000319214	Y	N	LL	
GC002	9:45 AM	10:30	CL, JW, SG, LL	17.6	482	2018GCRK066	O. mykiss	18.2	116	900.226000319278	Y	N	CL	
CC002	7:36 AM	9:15	JN, JW, CL, LL, NJ, KJ, PS, SG	16.33	477	2018CALE001	O. mykiss	215.3	263	900.228000613704	Y	N	LL	
CC002	7:36 AM	9:15	JN, JW, CL, LL, NJ, KJ, PS, SG	16.33	477	2018CALE002	O. mykiss	7.5	82	900.226000319280	Y	N	LL	
CC002	7:36 AM	9:15	JN, JW, CL, LL, NJ, KJ, PS, SG	16.33	477	2018CALE003	O. mykiss	125.2	216	900.228000613705	Y	N	LL	
CC002	7:36 AM	9:15	JN, JW, CL, LL, NJ, KJ, PS, SG	16.33	477	2018CALE004	O. mykiss	14.3	109	900.226000319268	Y	N	LL	
CC001	9:41 AM	11:10 AM	JN, JW, CL, LL, NJ, KJ, PS, SG	16.3	547	2018CALE005	O. mykiss	11.5	95	900.226000319336	Y	N	LL	
CC001	9:41 AM	11:10 AM	JN, JW, CL, LL, NJ, KJ, PS, SG	16.3	547	2018CALE006	O. mykiss	7.3	82	900.226000319302	Y	N	LL	
CC001	9:41 AM	11:10 AM	JN, JW, CL, LL, NJ, KJ, PS, SG	16.3	547	2018CALE007	O. mykiss	10.1	89	900.226000319332	Y	N	LL	
CC001	9:41 AM	11:10 AM	JN, JW, CL, LL, NJ, KJ, PS, SG	16.5	547	2018CALE008	O. mykiss	5.2	67	900.226000319373	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE009	O. mykiss	9.3	84	900.226000319357	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE010	O. mykiss	7.8	84	900.226000319347	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE011	O. mykiss	5.4	75	900.226000319323	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE012	O. mykiss	10.4	86	900.226000319300	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE013	O. mykiss	8.5	85	900.226000319231	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE014	O. mykiss	12.5	94	900.226000319244	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE015	O. mykiss	8.3	82	900.226000319287	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE016	O. mykiss	10.2	93	900.226000319230	Y	N	LL	
CC003	7:21 AM	8:45	JW,CL, LL, KJ, JT, SG	14	489	2018CALE017	O. mykiss	9.4	86	900.226000319212	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM029	O. mykiss	5.35	68	900.226000319284	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM030	O. mykiss	4.23	66	900.226000319260	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM031	O. mykiss	4.35	65	900.226000319291	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM032	O. mykiss	3.25	65	900.226000319292	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM033	O. mykiss	4.86	69	900.226000319295	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM034	O. mykiss	3.02	60	NA	Y	N	LL	
AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM035	O. mykiss	20.6	125	900.226000319250	Y	N	JW	Blackspot

AC004	8:30	10:10	CL, JW, SG, DT, LL, CG	16.50	390	2018ALM036	O. mykiss	3.06	60	NA	Y	N	JW	
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM037	O. mykiss	17.5	109	900.226000319246	Y	N	LL	Blackspot and scar on side
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM038	O. mykiss	36.5	145	900.226000319258	Y	N	LL	severe blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM039	O. mykiss	14.8	79	900.226000319263	Y	N	LL	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM040	O. mykiss	24.9	109	900.226000319201	Y	N	CL	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM041	O. mykiss	12.5	94	900.226000319218	Y	N	JW	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM042	O. mykiss	18.6	106	900.226000319269	Y	N	JW	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM043	O. mykiss	20.2	111	900.226000319200	Y	N	JW	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM044	O. mykiss	19	108	900.226000319311	Y	N	JW	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM045	O. mykiss	42.3	146	900.226000319257	Y	N	LL	Blackspot
AC003	11:30	13:03	CL, JW, SG, DT, LL, CG	15.38	401	2018ALM046	O. mykiss	16.8	110	900.226000319290	Y	N	LL	Blackspot
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM047	O. mykiss	7.7	84	900.226000319343	Y	N	LL	Minor blackspot
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM048	O. mykiss	13.8	98	900.226000319306	Y	N	LL	Minor blackspot
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM049	O. mykiss	13	100	900.226000319349	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM050	O. mykiss	9.6	91	900.226000319312	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM051	O. mykiss	14.1	102	900.226000319315	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM052	O. mykiss	12.8	103	900.226000319382	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM053	O. mykiss	10	91	900.226000319365	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM054	O. mykiss	445	345	900.228000613703	Y	N	LL	Blackspot
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM055	O. mykiss	9.4	92	900.226000319363	Y	N	LL	
AC002	8:13	9:38 AM	CL, JW, LL, SG, KJ	17.06	462	2018ALM056	O. mykiss	10.2	90	900.226000319390	Y	N	LL	
AC001	10:30	12:02 PM	CL, JW, LL, SG, KJ	16.89	462	2018ALM057	O. mykiss	23	119	900.226000319378	Y	N	CL	
AC001	10:30	12:02 PM	CL, JW, LL, SG, KJ	16.89	462	2018ALM058	O. mykiss	25.1	115	900.226000319396	Y	N	CL	
AC001	10:30	12:02 PM	CL, JW, LL, SG, KJ	16.89	462	2018ALM059	O. mykiss	20.8	117	900.226000319368	Y	N	LL	Blackspot
AC001	10:30	12:02 PM	CL, JW, LL, SG, KJ	16.89	462	2018ALM060	O. mykiss	28.2	129	900.226000319380	Y	N	CL	Minor blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM001	O. mykiss	43.06	146	900.226000319370	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM002	O. mykiss	15.14	111	900.226000319353	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM003	O. mykiss	-	199	900.226000319320	Y	N	LL	Blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM004	O. mykiss	17.2	109	900.226000319322	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM005	O. mykiss	13.3	102	900.226000319339	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM006	O. mykiss	15.09	107	900.226000319313	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM007	O. mykiss	8.33	89	900.226000319367	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM008	O. mykiss	-	248	900.226000319355	N	N	LL	Blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM009	O. mykiss	12.92	103	900.226000319350	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM010	O. mykiss	21.42	119	900.226000319366	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM011	O. mykiss	19.34	117	900.226000319375	Y	N	JW	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM012	O. mykiss	16.51	111	900.226000319326	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM013	O. mykiss	23.78	122	900.226000319387	Y	N	JW	Blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM014	O. mykiss	26.74	132	900.226000319376	Y	N	JW	Blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM015	O. mykiss	30.42	141	900.226000319319	Y	N	LL	Blackspot
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM016	O. mykiss	32.1	136	900.226000319352	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM017	O. mykiss	13.3	103	900.226000319314	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM018	O. mykiss	32.7	138	900.226000319391	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM019	O. mykiss	25.26	129	900.226000319310	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM020	O. mykiss	11.5	97	900.226000319372	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM021	O. mykiss	81.27	186	900.226000319301	Y	N	LL	

Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM022	O. mykiss	19.01	117	900.226000319384	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM023	O. mykiss	14.39	104	900.226000319316	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM024	O. mykiss	11.97	102	900.226000319397	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM025	O. mykiss	10	95	900.226000319388	N	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM026	O. mykiss	14.48	106	900.226000319360	N	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM027	O. mykiss	18.58	115	900.226000319321	Y	N	LL	
Mazzone	10:22	12:00 PM	JW, LL, CV, SG, JN	15.9	545	2018ALM028	O. mykiss	23.03	122	900.226000319348	Y	N	LL	

GUADALUPE RIVER 2018 ADULT SALMONID MIGRATION MONITORING USING THE VAKI RIVERWATCHER PASSIVE MONITORING SYSTEM

January 30, 2018 - May 31, 2018



Prepared by:

Santa Clara Valley Water District

Environmental Mitigation and Monitoring Unit

January 30, 2019

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INTRODUCTION

Steelhead (*Oncorhynchus mykiss*) in the Central California Coast (CCC) Distinct Population Segment (formerly Evolutionarily Significant Unit) were listed as threatened by the National Marine Fisheries Service (NMFS) in 1997. Due to their protected status, the Santa Clara Valley Water District (SCVWD) decided to implement a noninvasive means of documenting steelhead passage through the fishways. The equipment chosen to accomplish the task was the Vaki Riverwatcher (Vaki), a computer-based fish counter which employs scanner plates and a digital camera to capture videos and silhouette images of fish as they pass between the plates. The Vaki provides information on the occurrence and timing of fish migration both upstream and downstream of the counter.

The Alamitos fish ladder is located 32 kilometers upstream of the South San Francisco Bay on the Guadalupe River between Coleman Road and Blossom Hill Road, just downstream of Almaden Lake in San Jose, California. The fish ladder was installed in November 1999 at the Alamitos Drop Structure, a 13-foot tall structure that had previously created an impassable barrier to fish migration. The installation of the Alamitos Fishway opened up an additional 27 kilometers of upstream habitat for migrating fish. The Vaki was first deployed in the most downstream weir of the Alamitos Fishway for three monitoring seasons (years 1-3) from 2003 to 2006.On January 30th, 2018, the Vaki was reinstalled at the Alamitos fish ladder for a fourth season of monitoring following a 12-year break at this location; the 2018 monitoring year will be the focus of this report. The Vaki provided documentation of anadromous fish passage through the Alamitos Fishway, confirming that the fish ladder afforded passage for salmonids around the drop structure, providing seasonal continuity of fish passage in the Guadalupe system from the San Francisco Bay to upstream tributaries.

INSTALLATION, MAINTENANCE, AND METHODS

The Vaki was installed on January 30, 2018. This is later in the season than originally intended, as installation was delayed due to unforeseen complications with fabrication and implementation. Initially, the Vaki was unintentionally and unknowingly installed approximately 0.3 meters above the bottom of the channel due to a piece of woody debris sitting on the bottom of the channel. This allowed for fish to pass under the counter and not be recorded by the system. The issue was resolved on March 6, 2018 by removing the wood and lowering the Vaki to sit flush on the bottom of the channel.

The counter itself is a rectangular-shaped unit outfitted with infrared light emitting diodes on the interior and is completely submerged underwater within the fish ladder. Adult fish are directed through the counter opening by use of weirs in the ladder, and when it swims through the counter and breaks the plane of light beams, the fish is scanned and

a resulting silhouette image is sent to the onsite computer. Other information recorded as the fish passes includes the speed the fish was traveling, the direction the fish was moving (upstream or downstream), the body depth of the passing fish (for depth to length ratios), along with the date and time. A fish detection then triggers an underwater digital camera which records a 4.1 second video for fish traveling upstream or a 14.4 second video for fish traveling downstream. This enables the user to scan through the videos to confirm the presence of a fish and improves confidence in species identification. All the data collected by the Vaki are stored by the attached onsite computer. Data is manually downloaded twice per week and stored on the SCVWD network. The files are manually vetted as soon as possible.

The Vaki was maintained and cleaned twice a week by removing debris and algal build up on the scanner plates and plexiglass in front of the camera with a Mr. Long Arm brush. Data was manually downloaded from the onsite database, which was reset during each of these checks.

Because this Vaki runs off solar power, there were a few instances after several cloudy and rainy days where the battery reserve would drop so low that the Vaki would only record a silhouette image for each detection with no accompanying video. The Vaki completely lost power due to this same issue on the nights of March 22 and 23, 2018, but it was restarted the morning on March 24. The Vaki also had a brief 3-hour cessation on March 6, 2018 when the large woody debris beneath the Vaki was removed. One factor that must also be considered is that during the time of cleaning fish can still move up and down through the system and they will not be detected by the Vaki. It is a brief window, but there is a potential that migrating fish could be missed during cleaning and maintenance. These are all periods that migrating fish could have been missed.

The Vaki records silhouettes and videos off all items large enough to break the plain of the diodes. Scanned infrared silhouettes and video images were reviewed to ensure that only fish passage events were included in the overall passage counts. Video images were used to identify fish to species when conditions provided clear images. Silhouettes can also be used to identify the fish to species if identifying characteristics are depicted. Detections without videos were only sorted into specific species categories if the silhouette was particularly clear and the confidence level was high, otherwise these detections were sorted into the “unknown fish” category. Length to depth ratios were used to estimate the length of a specific individual based upon their body depth as detected by the Vaki. The length to depth ratios for *O. mykiss* were 4.1:1 for small and medium fish (<300 mm) and 4.8:1 for large fish (Cuthbert et al. 2012).

Steelhead with a standard length greater than 350 mm were classified as adult *O. mykiss*, while anything 350 mm and below were determined to be juveniles (Moyle,

2002). The scanner plates trigger a detection and a video recording only when a body depth of 40 mm or greater is detected. This results in a lack of detection for *O. mykiss* with an estimated fork length of 159 mm or less.

Only *O. mykiss* detections in the adult size range were analyzed to provide an estimate of the actual number of individual fish recorded. Juvenile fish could not be analyzed as their body depth could result in no detections on the Vaki and juvenile fish could travel through the weir bars limiting the ability to assess up and down movement. In attempt to reduce repeated detections of the same fish, data were analyzed using a direction, timing, and size criteria. A series of detections were considered the same fish if two or more detections occurred in an up to down or down to up pattern, were within 5 mm of body depth, and occurred within a 15-minute time period.

RESULTS

During the monitoring season, several native and non-native fish were documented passing through the Vaki. *O. mykiss*, Sacramento sucker (*Catostomus occidentalis*), common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), *Lepomis spp.*, goldfish (*Carassius auratus*), *Pomoxis spp.,* brown bullhead (*Ameiurus nebulosus*), and prickly sculpin (*Cottus asper*) were all positively identified from the Vaki video footage and silhouettes. Examples of positive identifications can be seen in Appendix A. Unknown fish detections were instances where fish were detected, but they could not be identified to species based on the silhouette or video. There was a total of 1,109 fish detections throughout the time the Vaki was installed with *O. mykiss* being the most commonly detected fish with 355 detections (Figure 1). After *O. mykiss* detections, carp and goldfish were the second largest group of fish detected with 310 detections.

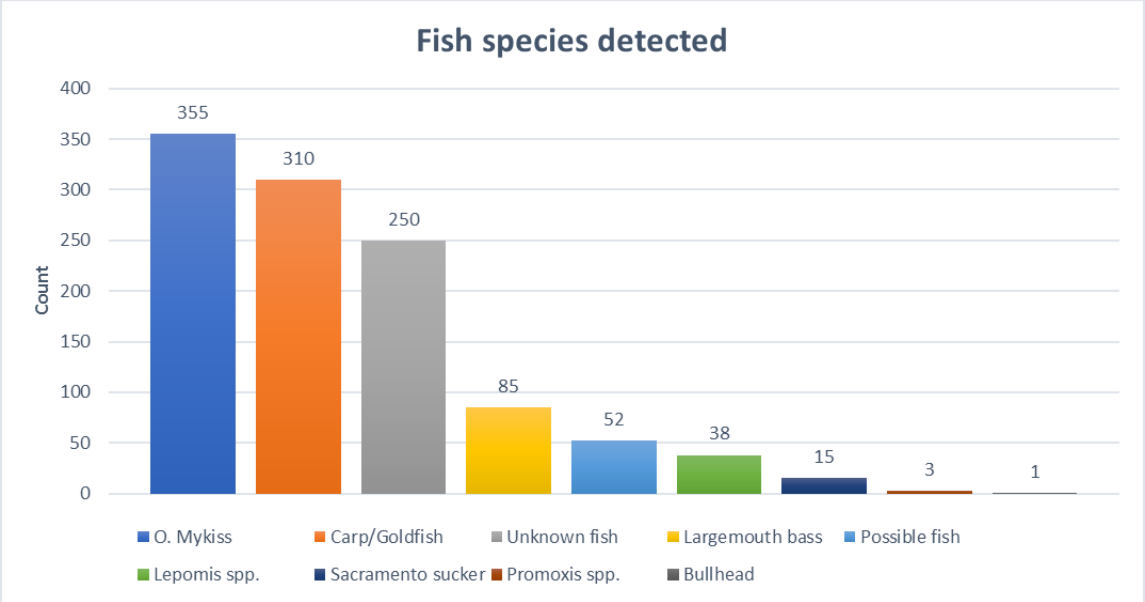


Figure 1: Number of detections of each fish species throughout the Guadalupe River Vaki deployment period.

Of the 355 *O. mykiss* detections, 167 recorded were moving upstream and 188 were moving downstream (Table 1 and Figure 2). There was a total of 31 Vaki detections classified as *O. mykiss* in the adult size range, with 14 moving upstream and17 going down. These are not individual fish but are just individual detections.

Table 1: Total *O. mykiss* detections based on age classification and direction of movement.

Age Class	Upstream	Downstream
Juvenile (≤350 mm)	153	171
Adult (>350 mm)	14	17
Total	167	188

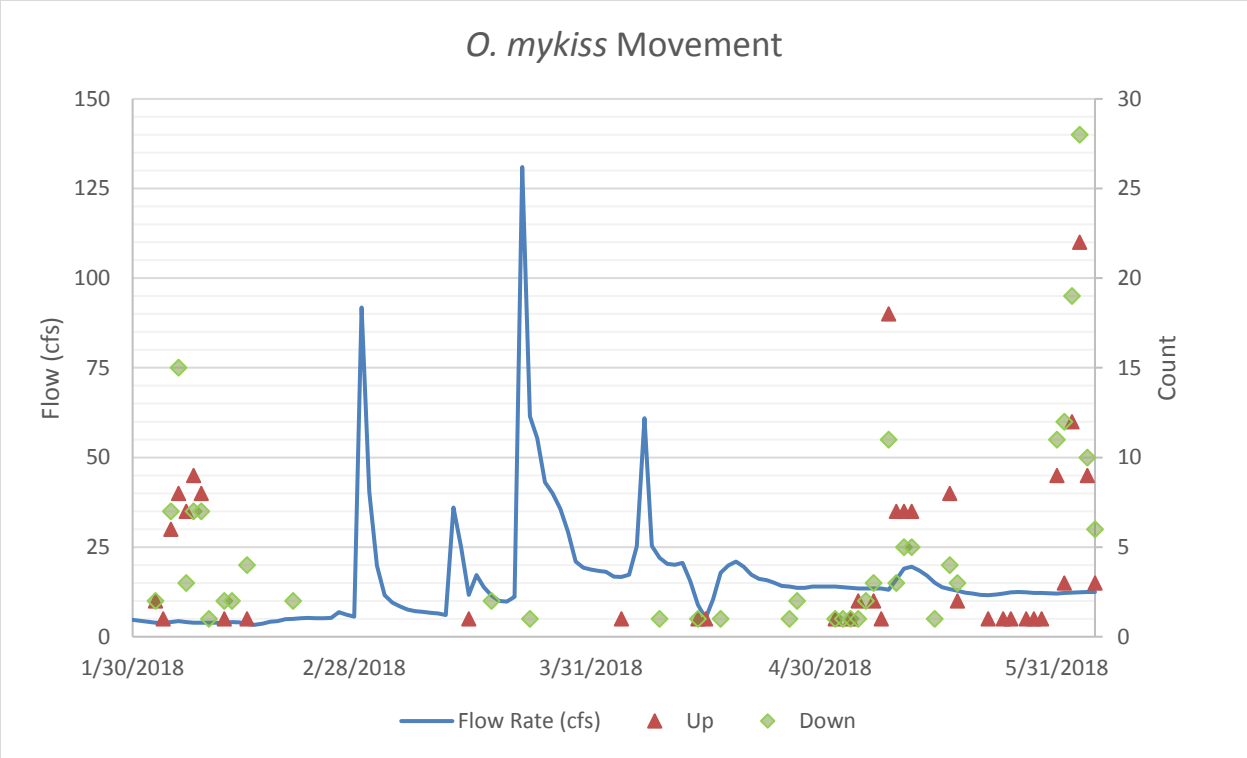


Figure 2: *O. mykiss* detections per day in relation to cubic feet per second daily averages on the Guadalupe River stream gage ALERT 5023b above Almaden Expwy.

The size range of *O. mykiss* detected ranged from 160 mm to 610 mm. The timing and estimated size of adult *O. mykiss* detections can be seen in Figure 3. The size and timing of juvenile movement was not included in this figure as it does not provide a complete picture of the movement of juvenile *O. mykiss* due to the size limitation of the Vaki software. The average estimated size of adult fish moving upstream was 388 mm and downstream was 410 mm. The three largest *O. mykiss* detected were estimated at 610 mm, 590 mm, and 580 mm and were all moving downstream (Figure 3 and 4).

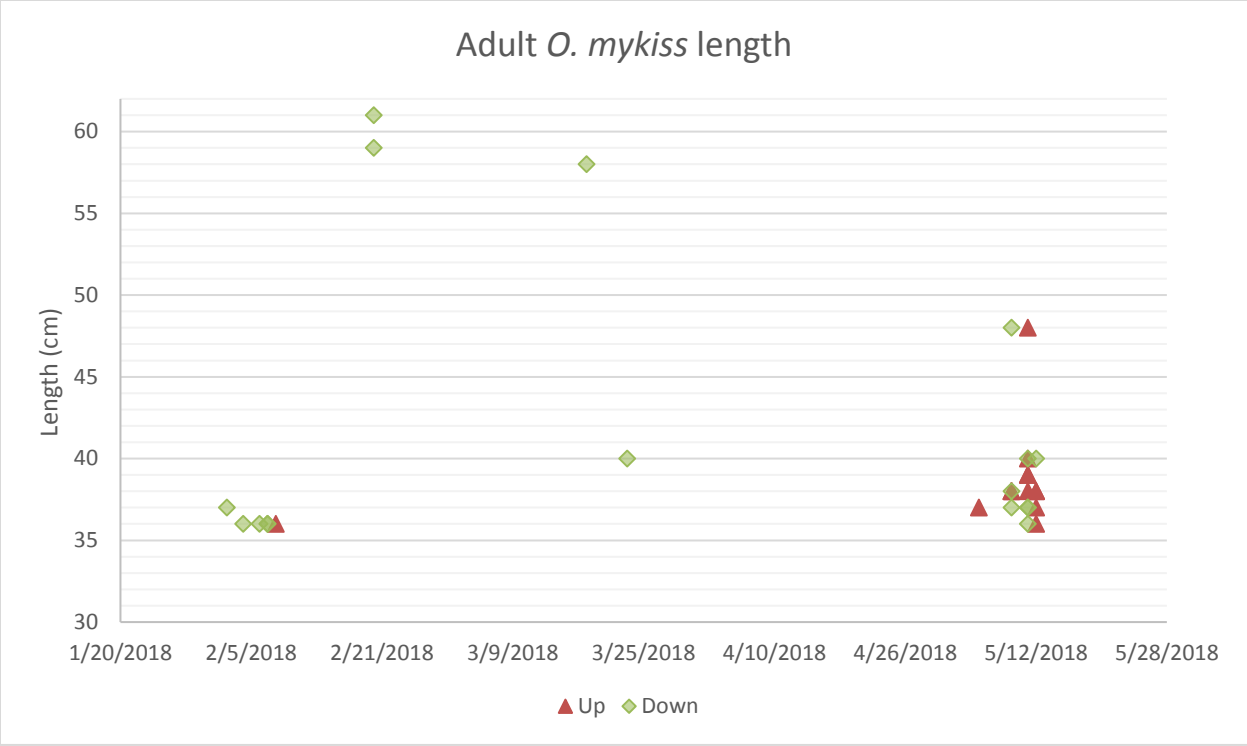


Figure 3: Adult O. mykiss estimated length and date of migration (adult O. mykiss were identified as fish greater than 350 mm).



Figure 4: Images of adult *O. mykiss* captured by the Vaki RiverWatcher. A 610 mm total length (left) moving downstream and 380 mm total length (right) moving upstream.

DISCUSSION

Ideally the Vaki would have been installed by October or November to ensure capture of the entire steelhead migration season. Adult *O. mykiss* typically begin their upstream

migration between December and March, peaking in January and February (Moyle, 2002). With the Vaki being installed on January 30th, two months of potential migration data was not recorded.

The data collected are particularly challenging to analyze and draw conclusions from due to the gap created in the initial install and late-season installation. The higher number of adults moving downstream versus upstream could be explained by these two issues. When the data were analyzed in attempt to reduce repeat detections the 31 adult sized range detections were reduced to 26 individuals with 14 of the fish recorded moving downstream and 12 passing upstream.

The 360 mm to 610 mm size range detected for adult *O. mykiss* is very broad. It is likely that some of the fish detections closer to the 360 mm size range are resident rainbow trout moving through the system. During the 2018 juvenile rearing monitoring conducted in the Guadalupe Watershed, the largest *O. mykiss* captured was 345 mm fork length, which would generate a total length greater than 350 mm. Only one fish in this size range was collected during that sampling effort and it made up less than 1% of the population (SCVWD 2019).

Limited movement of *O. mykiss* was observed during the large flow events (greater than 50 cfs at ALERT stream gage 5023b) that occurred in the month of March. No adult-sized fish were observed moving upstream in March or April. The concentration of *O. mykiss* observed in the beginning of February moving up- and downstream after the Vaki installation could have been the result of flow events that occurred in December and January.

The lack of Chinook salmon (*Oncorhynchus tshawytscha*) detections can be attributed to the late Vaki installation date on January 30th, which would be late for Chinook salmon migration. The 2018 abbreviated monitoring period provided more lessons learned than beneficial data. The shortcomings and technological issues that occurred in 2018 were taken into consideration for the WY 2019 monitoring. Through these experiences it is hoped that better data collection will occur moving forward.

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Santa Clara Valley Water District (SCVWD). 2019. Water Year 2018 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed. Prepared by the Environmental Mitigation and Monitoring Unit. San Jose, CA.

Moyle, P. B. (2002). *Inland fishes of California*. Berkeley: University of California Press.

Appendix A

Sample Silhouettes and Video Imag

Fish Silhouettes

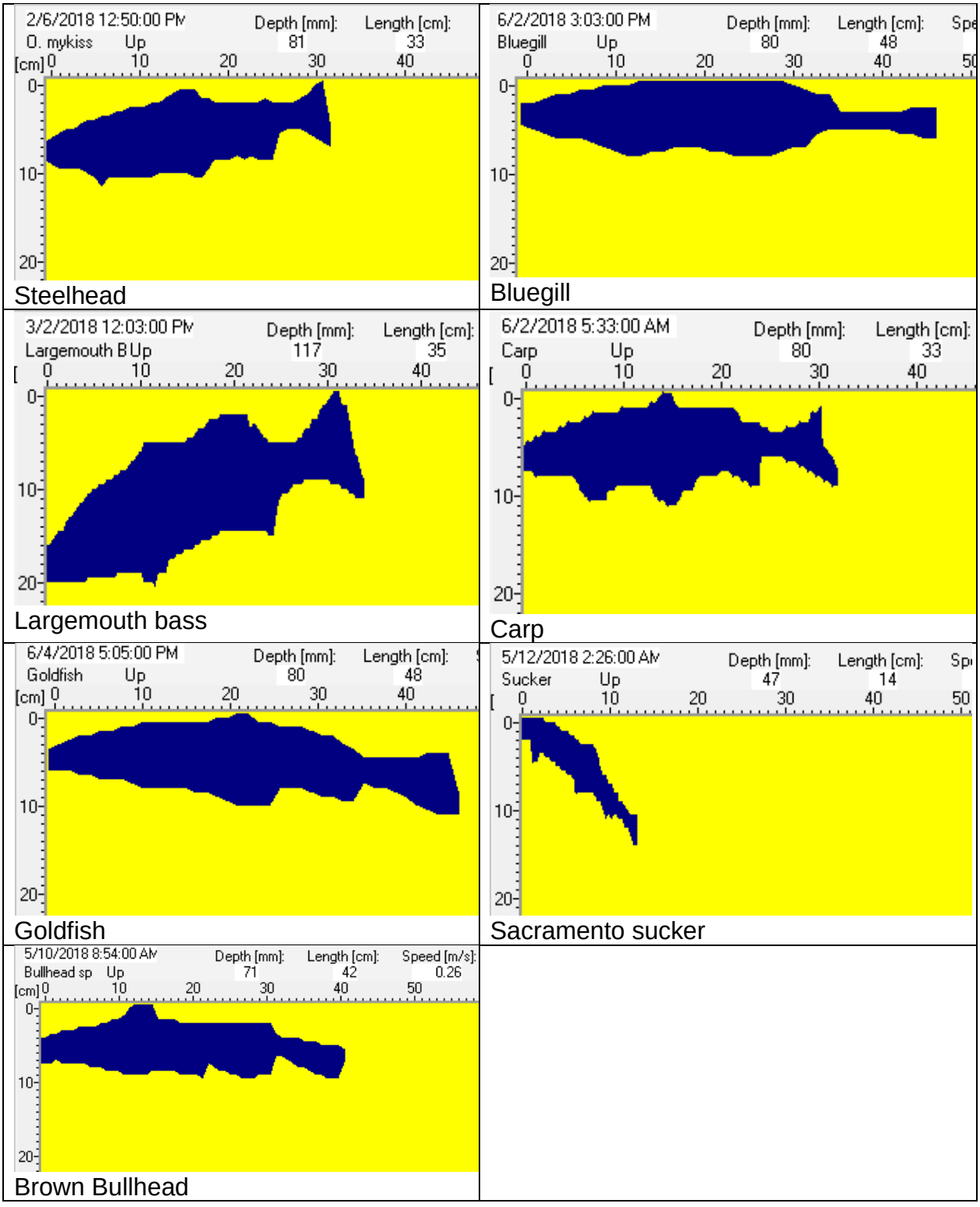


Figure 1: A sample of the silhouette images generated by the Vaki for each fish species in the report.

Fish Video Images

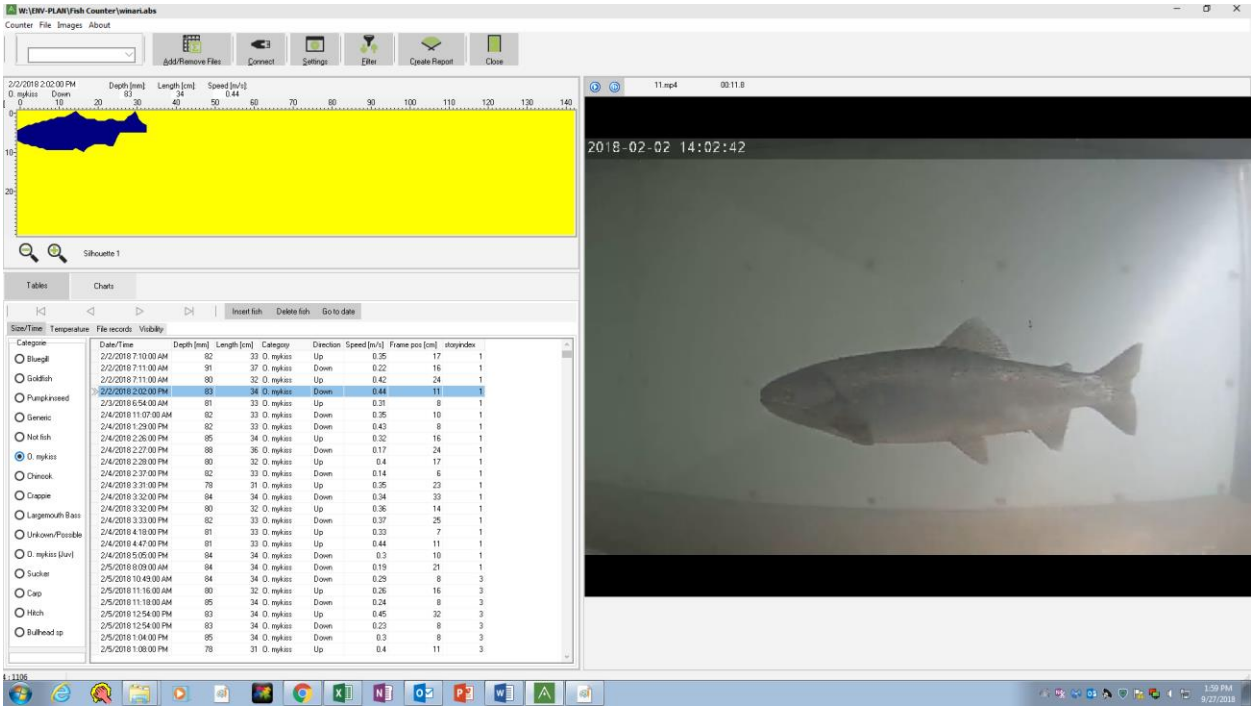


Figure 2: Vaki video image of an adult steelhead (*Oncorhynchus. mykiss*).

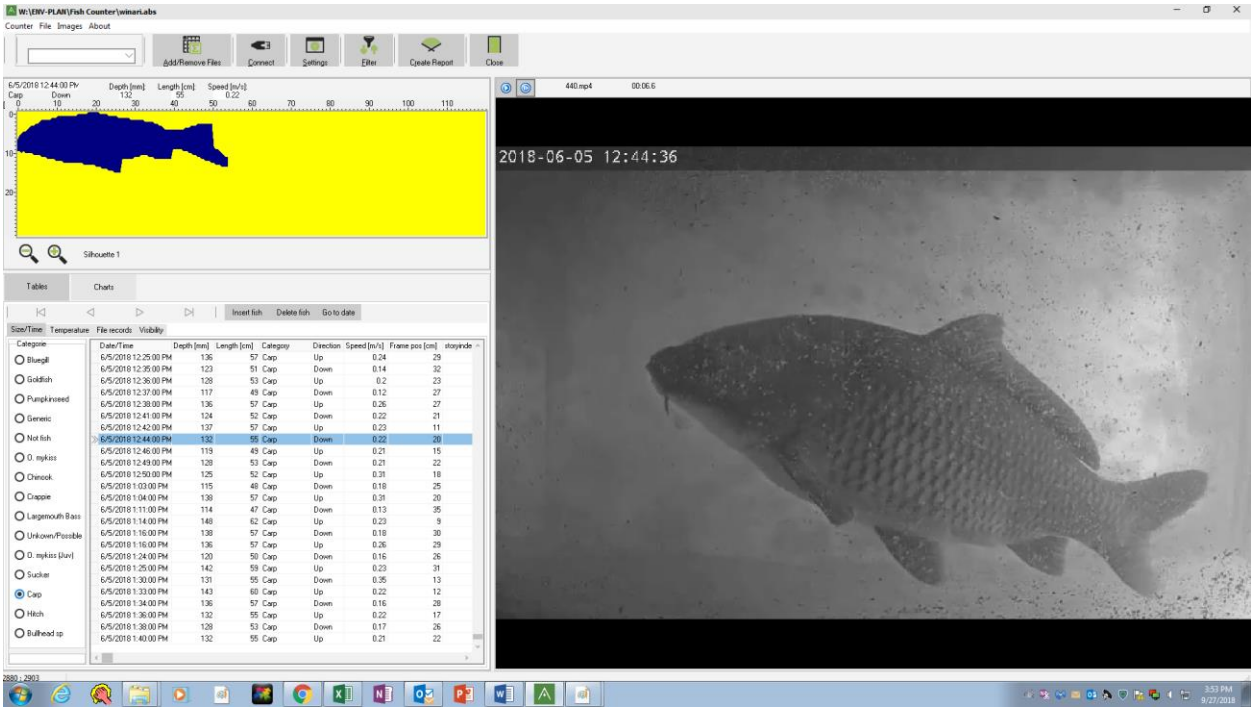


Figure 3: Vaki video image of a carp (*Cyprinus carpio*).

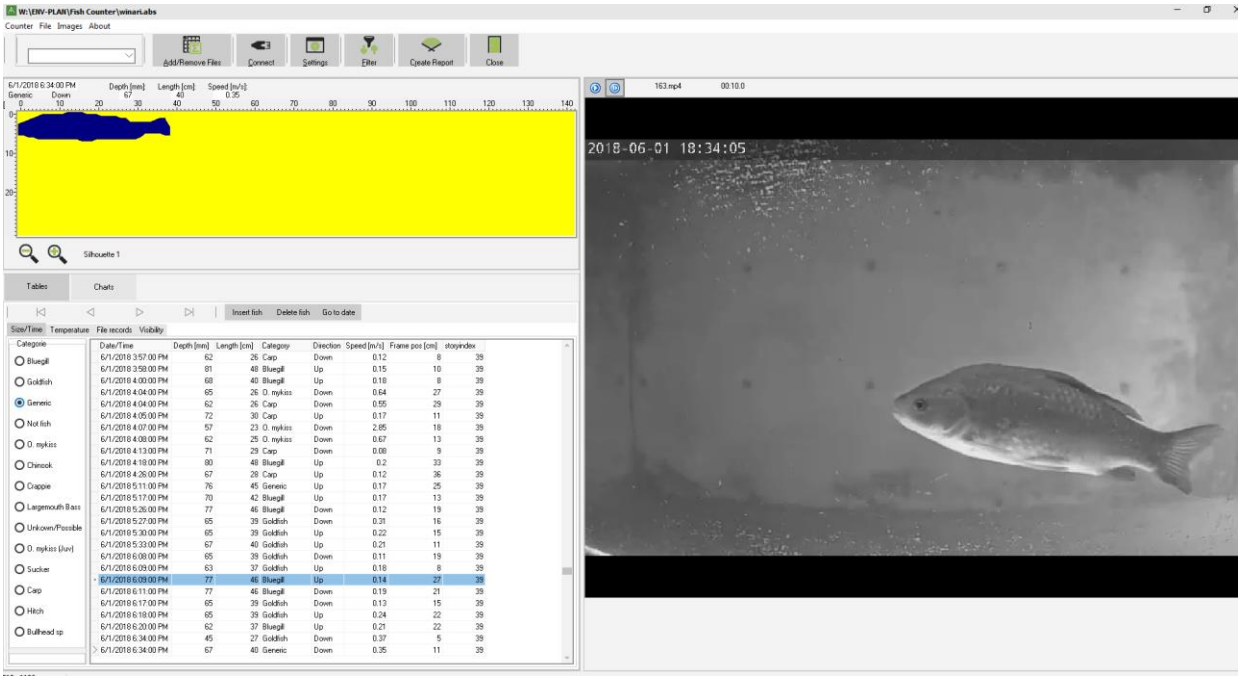


Figure 4: Vaki video image of a goldfish (*Carassius auratus)*.

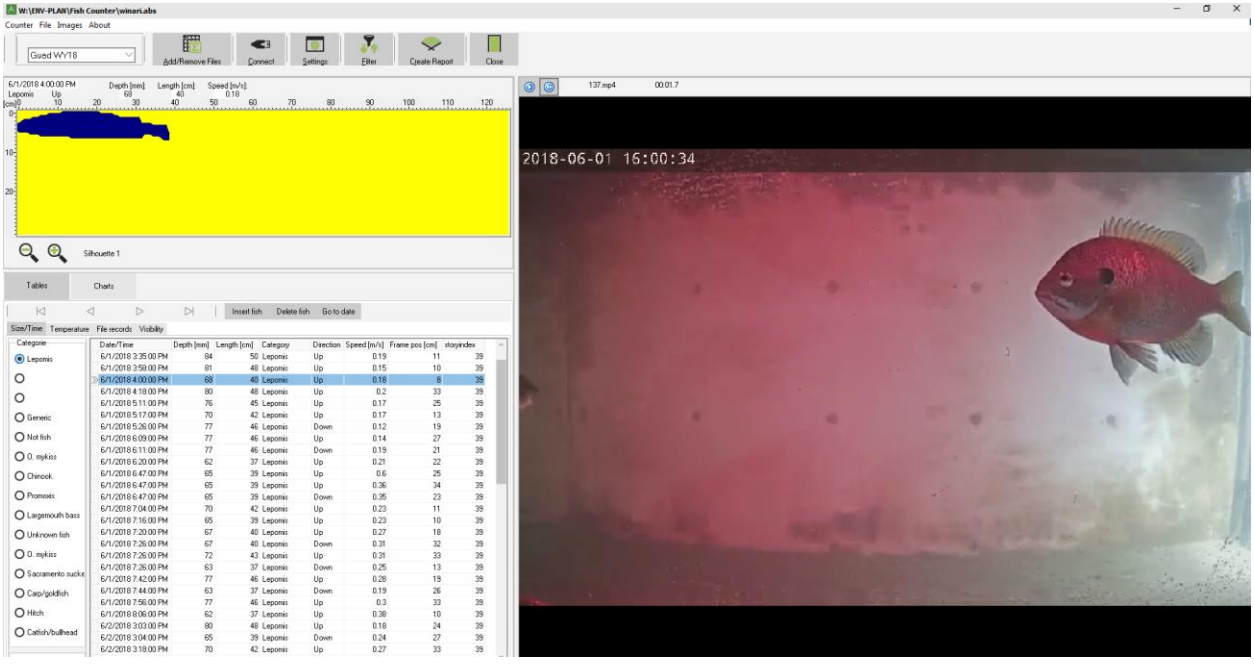


Figure 5: Vaki video image of a bluegill (*Lepomis macrochirus*; classified as *Lepomis spp*).

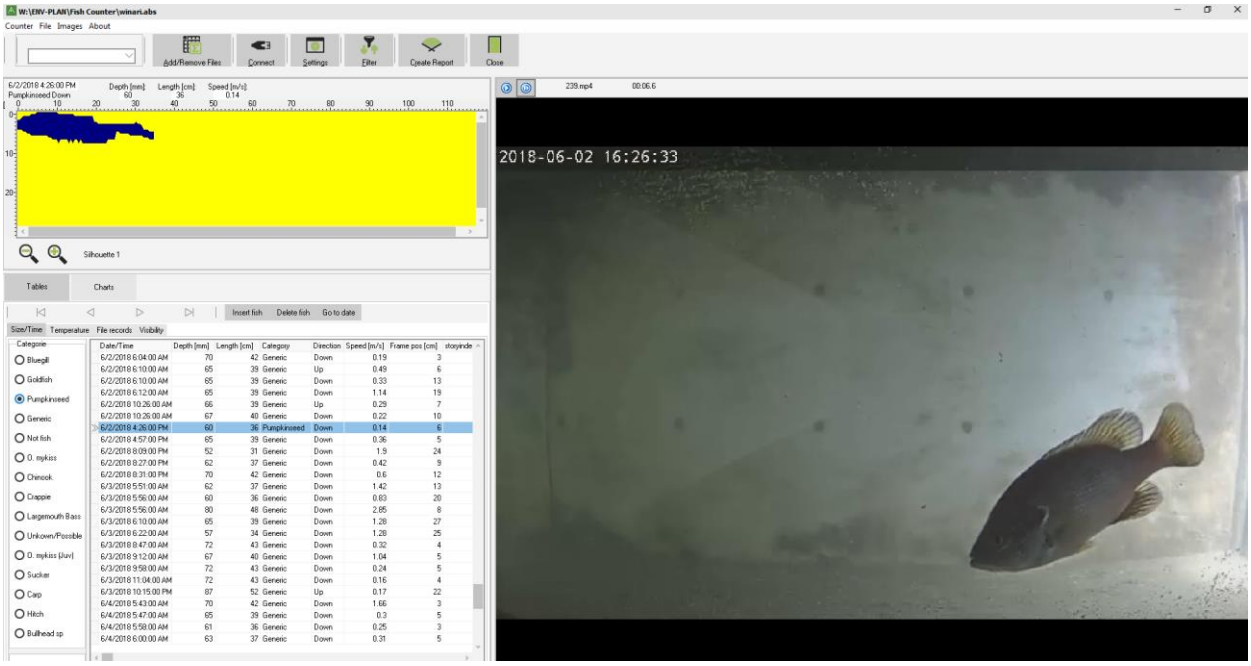


Figure 6: Vaki video image of a green sunfish (*Lepomis cyanellus*; classified as *Lepomis spp*).

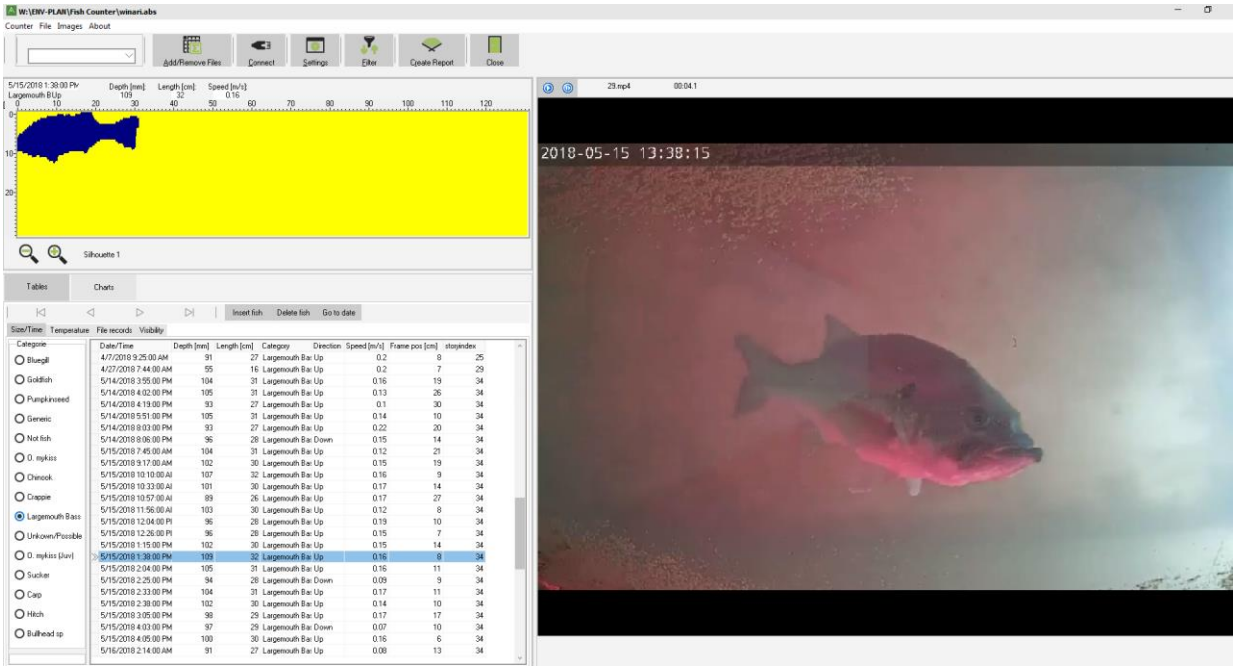


Figure 7: Vaki video image of a Largemouth bass (*Micropterus salmoides*).

2019 Guadalupe River Watershed Fisheries Monitoring

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Reports included:

2019 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed

Guadalupe River Watershed *Oncorhynchus mykiss* Migration Monitoring Using Passive Integrated Transponder Tags: Pilot Study

Guadalupe River 2018-2019 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System at the Alamitos Drop Structure

2019 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed



Prepared by:

Valley Water

Environmental Mitigation and Monitoring Unit

January 30, 2020

Executive Summary

Valley Water has been conducting juvenile steelhead (*Oncorhynchus mykiss, O. mykiss*) monitoring since 2004 as part of the downtown Guadalupe River Project. The monitoring was concluded in 2013, but Valley Water recommended the continuation and expansion of monitoring efforts to better understand *O. mykiss* numbers and distribution in the Guadalupe Watershed. In 2013 the Guadalupe River Project's Adaptive Management Team (AMT) approved the recommendation (No. 136) and in 2018 the National Marine Fisheries Service and California Department of Fish and Wildlife authorized the expansion of the monitoring under Section 10(a)1(A) take permit # 16417-2R and California Department of Fish and Wildlife Scientific Collecting Permit # 11325.

In fall 2019, monitoring was conducted at 24 stations in the Guadalupe Watershed, including stations in the Guadalupe River, Guadalupe Creek, Los Gatos Creek, Calero Creek, and Alamitos Creek. Multi-pass depletion backpack electrofishing was conducted at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Guadalupe Watershed. Appropriately sized *O. mykiss* were tagged with Passive Integrated Transponder (PIT) tags to study their movement within the Guadalupe Watershed.

Juvenile *O. mykiss* were present in the Guadalupe River, Guadalupe, Alamitos, and Calero Creek during fall 2019, with one (<0.01 *O* .mykiss/m), 34 (0.14 *O. mykiss*/m), 53 (0.29 *O. mykiss*/m), and eight (0.06 *O. mykiss*/m), individuals captured in each creek respectively. No *O. mykiss* were detected in Los Gatos Creek. Based on the size range of fish collected, it can be deduced that reproduction and successful summer rearing occurred, and multiple age classes were present.

Seven species of non-native fish were observed amongst the five systems sampled, representing 2% of the total number of fish observed in 2019. The Guadalupe River and Los Gatos Creek had the highest percentage of non-natives (4.8% and 16.5% respectively). In Los Gatos Creek, non-native pond loach (*Misgurnus anguillicaudatus*) were observed for the first time in Santa Clara County.

This juvenile rearing monitoring is part of a continuing effort to better understand *O. mykiss* distribution and abundance in the Guadalupe Watershed. This report contains the results and analysis of the juvenile rearing monitoring conducted from WY 2004 – 2019.

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1. Introduction

The United States Army Corps of Engineers in partnership with Valley Water (formerly the Santa Clara Valley Water District) constructed both the Guadalupe River Project (Downtown Project) and Upper Guadalupe River Project (UGRP). These projects together extend from approximately Norman Y. Mineta San Jose International Airport to Blossom Hill Road to protect downtown San Jose from Guadalupe River flooding. To offset the impacts of constructing the Downtown Project, the Guadalupe River Project Mitigation and Monitoring Plan (Downtown Project MMP) specified that a variety of mitigation be undertaken, including restoration of Guadalupe Creek from approximately Almaden Expressway to Masson Dam (Corps 2001a). The Downtown Project MMP also described the monitoring methods and measurable objectives for determining the success of mitigation. This included 10 years of monitoring for juvenile rearing of federally threatened Central California Coast Steelhead (*Oncorhynchus mykiss*; *O. mykiss* for the remainder of the document) at 12 stations in the mainstem of the Guadalupe River and eight stations within Guadalupe Creek to demonstrate whether the associated measurable objective was being met: "The Guadalupe River must continue to support juvenile rearing at a level that is consistent with pre-project conditions and environmental conditions not affected by the Guadalupe River Project." In 2018, Valley Water expanded the juvenile rearing monitoring to include areas outside of the Guadalupe River Project as well as into Los Gatos Creek, Alamitos Creek, and Calero Creek to improve understanding of juvenile *O. mykiss* distribution and densities, collect genetic information, and implement an *O. mykiss* tracking study using Passive Integrated Transponders (PIT).

Valley Water conducted the required juvenile rearing monitoring from WY 2004 to 2013, and the measurable objective was met in each year. Instead of ending the monitoring, Valley Water recommended continuing and expanding it to better understand *O. mykiss* numbers and distribution throughout the Guadalupe River watershed. In WY 2013, the Downtown Project Adaptive Management Team (Guadalupe AMT) approved the recommendation (No. 136) to continue juvenile rearing monitoring at five of the previous

monitoring stations on the Guadalupe River and expand the monitoring to 15 stations elsewhere in the watershed.

However, the Downtown Project permits did not authorize juvenile rearing monitoring at additional stations. From WY 2014 to WY 2017 juvenile rearing monitoring continued at the original permitted stations (as flow conditions allowed) while the permits for monitoring at additional stations were acquired. Ultimately, additional monitoring in the Guadalupe River watershed was authorized under National Marine Fisheries Service (NMFS) Section 10(a)1(A) permit number 16417-2R and California Department of Fish and Wildlife (CDFW) Scientific Collecting Permit #11325 for the Valley Water's Fisheries and Aquatic Habitat Collaborative Effort (FAHCE) Adaptive Fishery Management Baseline Data Collection Project.

To date, juvenile rearing monitoring results have been reported to the Guadalupe AMT in the annual Mitigation Monitoring Report (MMR) for the Guadalupe River Projects. Beginning in WY 2018 MMR, monitoring results were reported in a stand-alone document to facilitate distribution to and review by FAHCE stakeholders as well as the Guadalupe River Projects AMT. The 2019 results will continue in this fashion.

2. Methods

2.1 Station Selection

A total of 24 stations within the Guadalupe River watershed were sampled between October 9, 2019 and October 31, 2019. To provide continuity from the previous monitoring on Guadalupe River and Guadalupe Creek and maintain a long-term dataset, the 2019 sampling occurred at the same stations selected during the 2018 monitoring. These stations include a subset of the monitoring conducted in 2004-2017 as well as the expanded sites randomly selected in 2018. The 2018 monitoring report includes details associated with site selection (SCVWD, 2019).

Six stations each were sampled on both the Guadalupe River (Figure 1) and Guadalupe Creek (Figure 2). These stations were previously sampled in 2018, except for station GR006 on the Guadalupe River and GC001 on Guadalupe Creek which were repositioned due to safety and sampling difficulties. Dense vegetation and in channel changes required that GR006 be moved 50 m downstream. A homeless camp in proximity of GC001 forced the location to be move approximately 200 m upstream. These location changes are not expected to skew sampling results or yearly comparisons as the general location remained the same. Four stations were sampled on Los Gatos Creek, and the locations remained the same except that station LG001 was moved 130 m downstream (Figure 3). A fence was built around the access point of station LG001 which limited access with gear. Again, this change is not expected to reduce yearly comparisons as the deviation from the previous point was minimal. On Alamitos Creek, the four stations sampled in 2018 were resampled with an additional randomly selected site added in the system (Figure 4). It is likely that this additional site will rotate on a yearly basis and is primarily used as means to capture more *O. mykiss* for PIT tag implantation. Yearly comparisons will not occur for this rotating station. Sampling on Calero Creek occurred at three stations, all of which were previously sampled in 2018 (Figure 5).

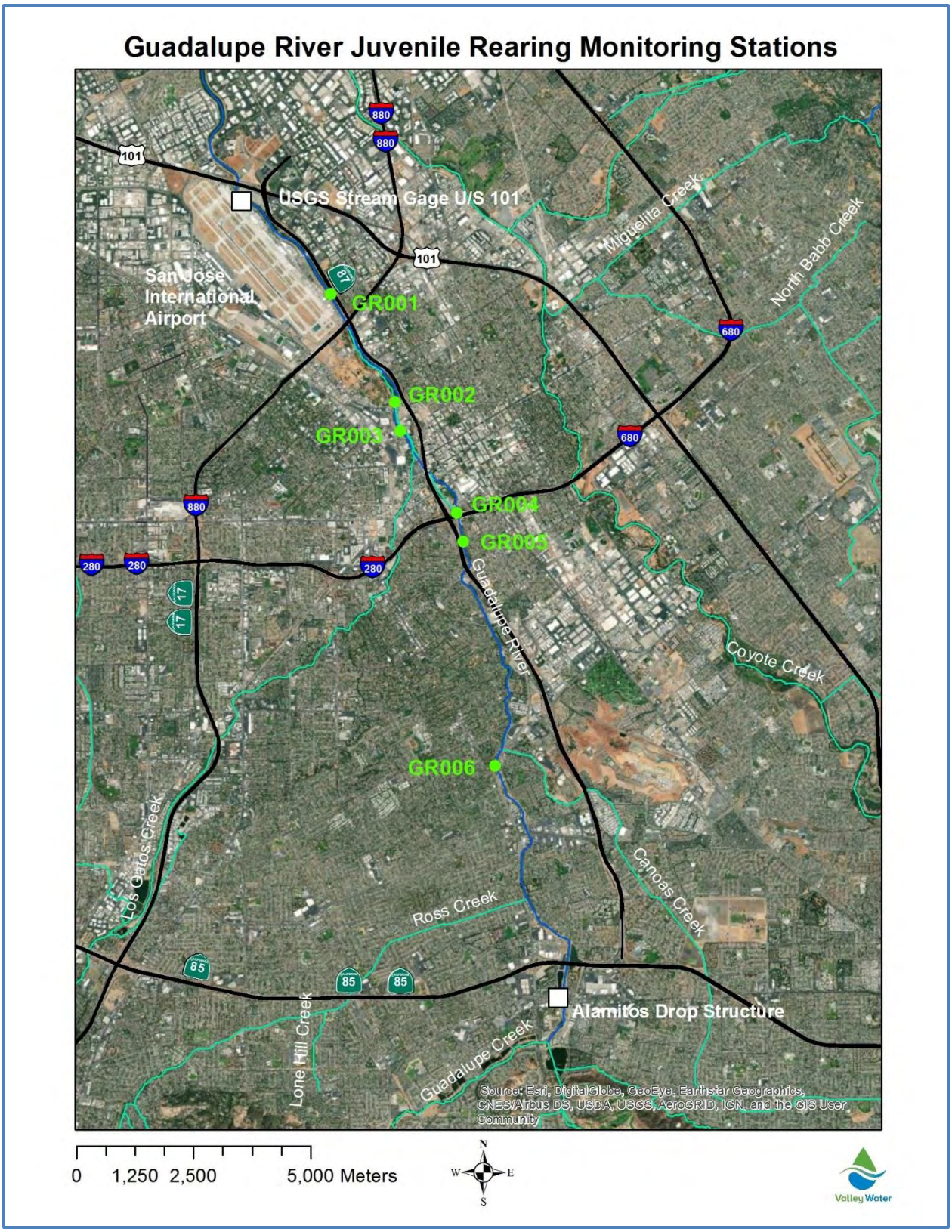


Figure 1: Guadalupe River juvenile rearing monitoring stations.

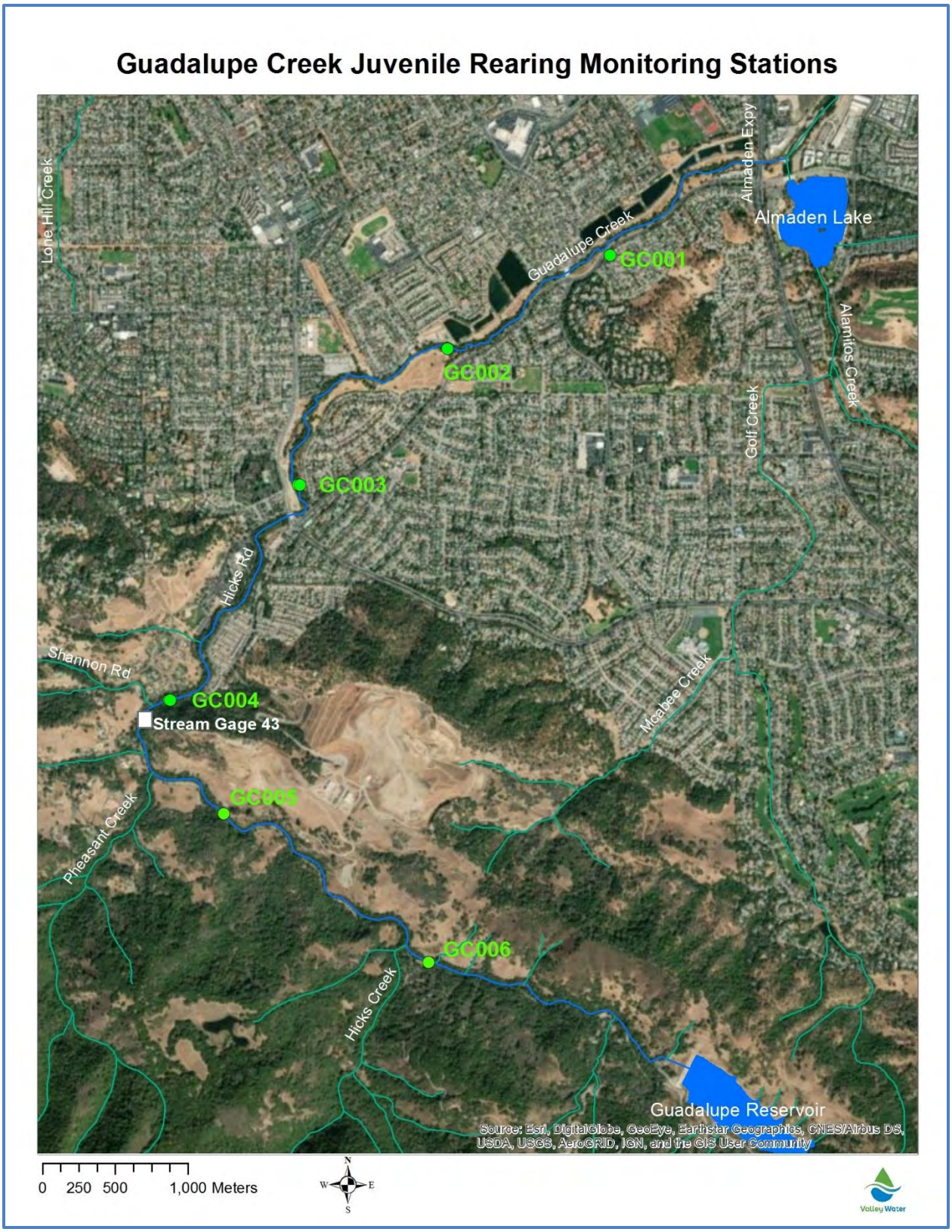


Figure 2: Guadalupe Creek juvenile rearing monitoring stations.

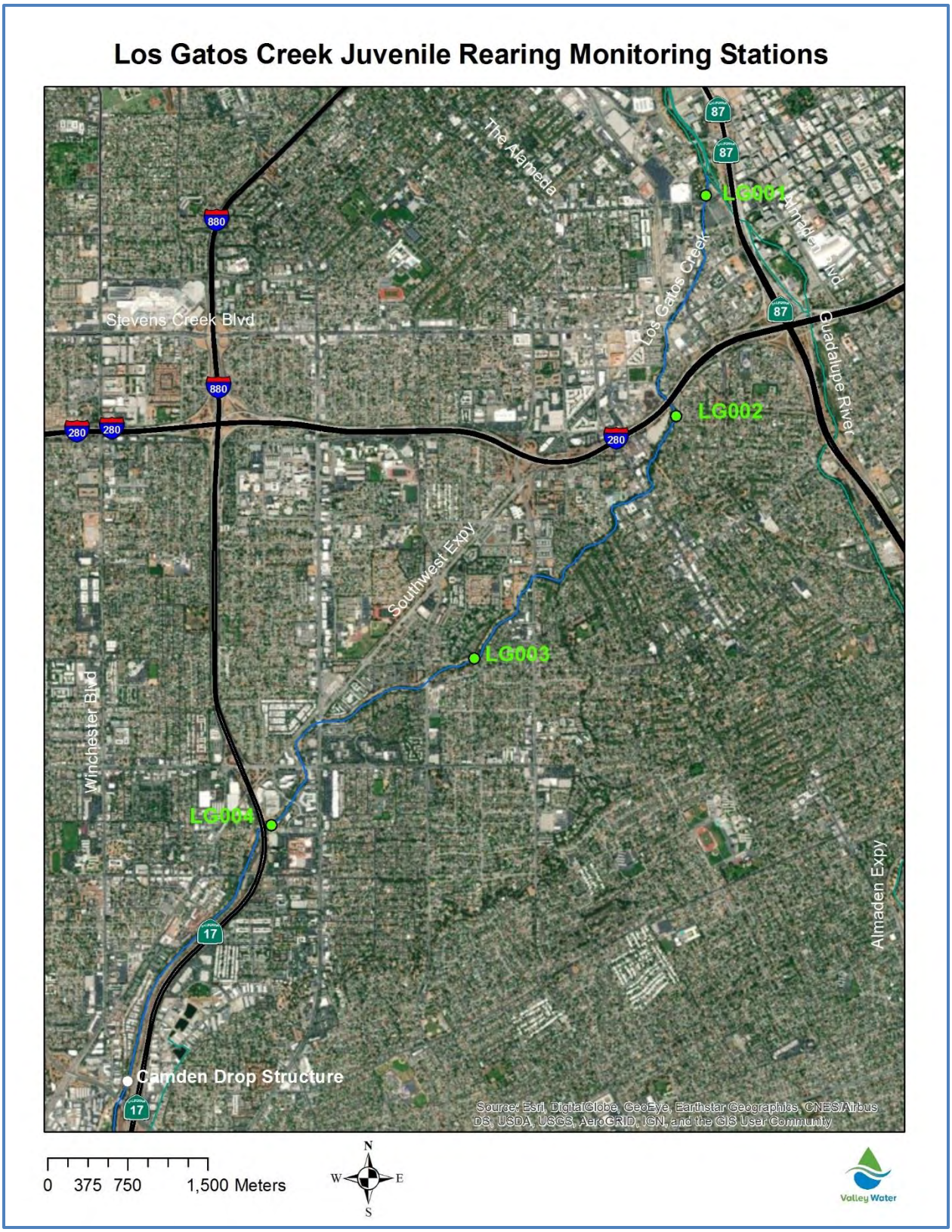


Figure 3: Los Gatos Creek juvenile rearing monitoring stations.

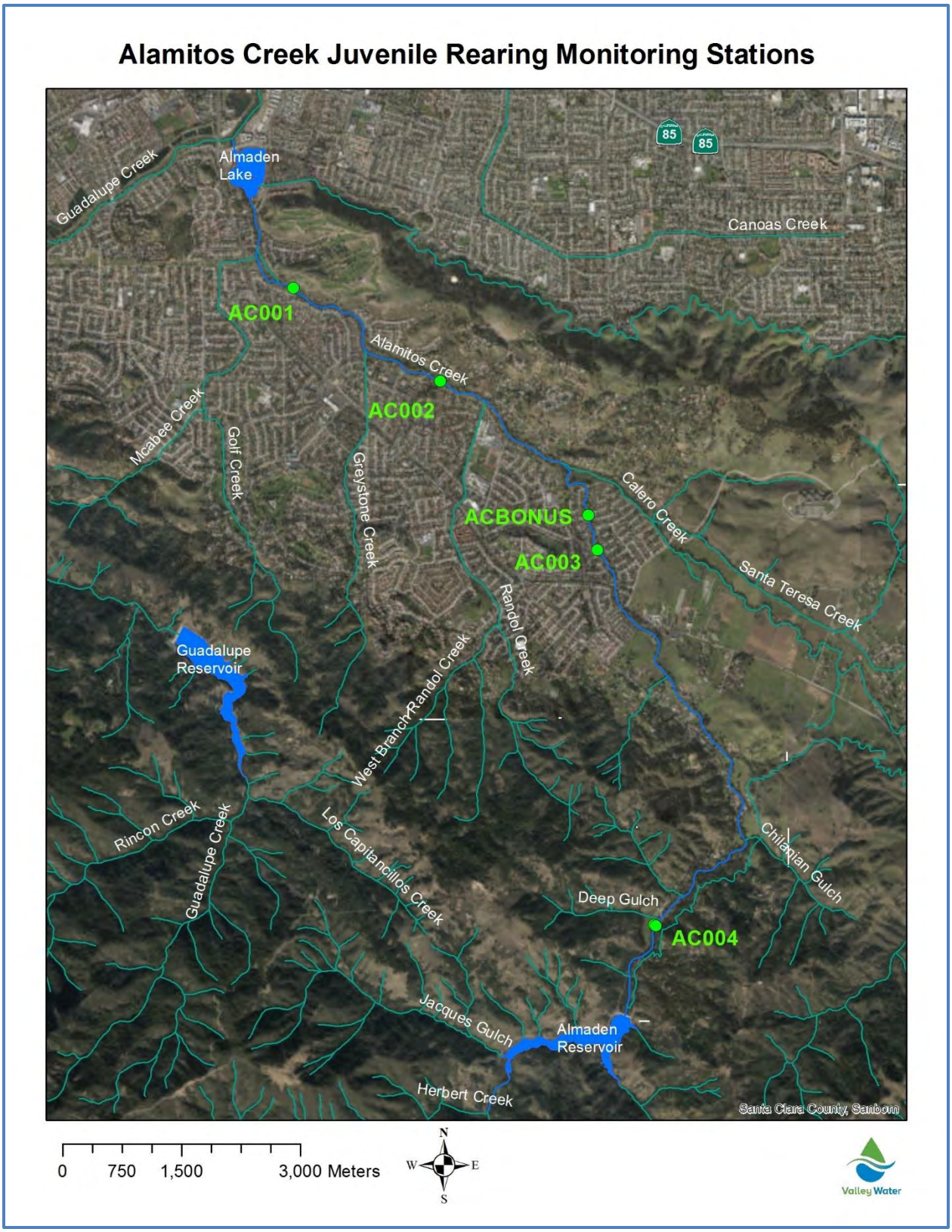


Figure 4: Alamitos Creek juvenile rearing monitoring stations.

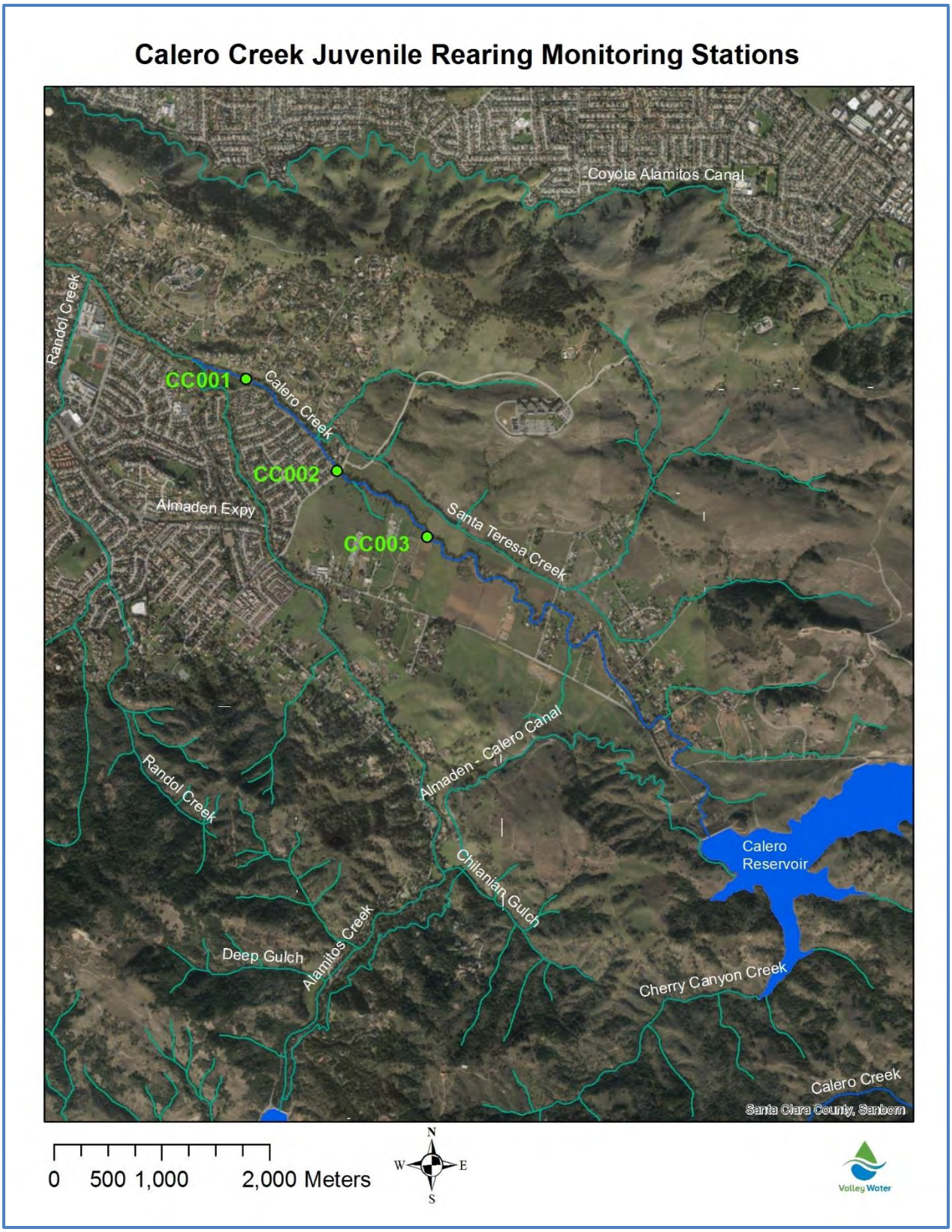


Figure 5: Calero Creek juvenile rearing monitoring stations.

2.2 Sampling Methods

Each monitoring station ranged between 35 and 45 m in length. The target length was 40 m, but deviations in length occurred based on the ability to install and secure block nets. Each station was set as close as possible to the station previously sampled and to include at least two distinct habitat types, described below. Multi-pass depletion backpack electrofishing was used at every monitoring station (Johnson et al. 2007). This method allowed for: consistency with previous juvenile rearing monitoring methods, the extrapolation of population estimates, and the sampling of a variety of habitat types.

Habitat Typing

Each monitoring station was habitat typed following Ode (2007) using the classifications described in Table 1. Average wetted width and depth were estimated and the presence of any anthropogenic influences (bridge, dam, etc.) was noted. Prior to the start of sampling, ambient conditions (weather) were noted and water quality parameters (dissolved oxygen, conductivity, turbidity, and temperature) were collected at the downstream end of the monitoring stations. Ocular estimates of percent cover of macrophytes/emergent vegetation, boulders, woody debris, undercut banks, overhanging vegetation, submerged roots (live and dead), and artificial structures were recorded for each monitoring station (Table 2). Each habitat feature was ranked on a 0-4 point scale described in Table 2, with 0 being absent and 4 being a very heavy presence. Primary and secondary substrate types were determined based upon ocular estimates (Table 3; Ode 2007).

Table 1: Habitat type classifications (Ode 2007).

Habitat Type	Description
Cascades	Short, high gradient drop in streambed elevation often accompanied by boulders and considerable turbulence.
Falls	High gradient drop in elevation of the streambed associated with an abrupt change in the bedrock.
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.

Riffles	Shallow sections where the water flows over coarse streambed particles that create mild to moderate surface turbulence.
Step-Run	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope.
Runs	Sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool.
Glides	A section of stream with little or no turbulence, but faster velocity than pools.
Pool	A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Table 2: Ocular estimate scale (Ode 2007).

Scale	0	1	2	3	4
Percent Coverage	0%	<10%	10-40%	40-75%	>75%
Descriptor	Absent	Sparse	Moderate	Heavy	Very Heavy

Table 3: Substrate classes

Particle Size	Size Category
Boulder	> 250 mm
Cobble	65-250 mm
Gravel	2.0-65 mm
Sand	<2.0 mm (gritty texture)
Silt/Clay	Not gritty
Bedrock	No individual particles

Electrofishing

Block nets were installed at both the upstream and downstream ends of sampling reaches to block immigration into and emigration out of sampling reaches. Electrofishing commenced from down to upstream and worked laterally across the stream to ensure

all portions of the wetted width were sampled. Smith-Root LR24 Backpack Electrofishing Units were used at all monitoring stations. As recommended in Johnson et al. 2007, in portions of the creeks that exceeded 7.0 m in width, two electrofishers were deployed, to provide adequate coverage of the channel. The LR24 quick set option was used to establish the initial power and waveform settings. The quick set output was verified with conductivity readings. Electrofishers were run using direct current, at a frequency of 30 Hz, duty cycle of 12%, and voltage that ranged between 150 and 230 volts. Each electrofisher operator(s) was flanked by two netters. Verbal communication and spatial awareness were used to ensure the entire width of the stream was covered. Triple-pass depletion electrofishing methods were deployed at all stations.

Fish Processing

Fish were held in aerated dark-colored containers during processing. Length measurements were recorded to the nearest millimeter at the fork of the tail (fork-length). For each pass, up to 30 individuals of each species were measured, and all additional individuals of that species were counted for a total number.

Carbon dioxide (CO_2) was administered to *O. mykiss* using Alka-Seltzer Gold, in doses to induce light narcosis (1 tablet per 2.5 liters of stream water). *O. mykiss* were exposed to the anesthesia for no more than 5 minutes. *O. mykiss* were observed for listing, and upon listing were removed from the anesthetizing solution, weighed, measured, tail-clipped for a genetic sample, and PIT tagged if large enough (≥65 mm fork-length).

Fin clips were taken for genetic analysis of all *O. mykiss* from the caudal fin. Clips were a 1-2 mm square. Medical grade scissors used to collect the clips were sterilized with an alcohol dilution with a final concentration of 60-80% isopropyl. Tissue samples were placed in sterile chromatography paper and placed in a labeled envelope denoting the field specimen number, species, stream, stream location, date, and fork-length. Tissues collected will be sent to the National Marine Fisheries Service Southwest Fisheries Science Center for analysis.

All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure. All *O. mykiss* 65 mm in fork-length or greater received a PIT tag. Biomark single-use preloaded needles were used in the tagging process. Prior to inserting PIT tags all *O. mykiss* were scanned to ensure they were not previously tagged. *O. mykiss* greater than or equal to 65 mm fork-length received 12 mm half-duplex PIT tags. *O. mykiss* larger than 150 mm fork-length received 23 mm tags. The permits allow for fish greater than 100 mm to be tagged with 23 mm tags, but to be conservative with the fishes' welfare, the minimum size was increased to 150 mm. PIT tags were scanned prior to insertion to verify they were viable. All PIT tag numbers and associated biological data for each fish from all Valley Water tagging is included in Appendix A.

After exposure to the anesthesia and all procedures, fish were placed in an aerated dark-colored receptacle, then transferred to an in-channel live car for recovery, and then released.

2.3 Data Analysis

MicroFish 3.0 was used to calculate population estimates for each station using a maximum-likelihood iterative process (MLIP); the associated standard errors and 95% confidence intervals (95% CI) are reported. This method uses the number of fish captured (n) and the difference in capture between electrofishing passes (i.e., depletion rate) to calculate an estimate of fish likely to have been present but not captured, thus generating a population estimate (N) for each station. Population estimates are restricted to the sampled areas and are only an index of the overall population. If the number of a particular species was too low (i.e., only one fish was captured) or all fish of a particular species were captured on the first pass, then MLIP population estimate could not be produced. If the lower confidence interval was less than the total catch it was set equal to total catch, as it is certain at least that many fish were present in the sampling reach. These calculations assume emigration and immigration were prevented by the erection of upstream and downstream block nets. It is assumed that shocking efficiency did not change between passes and that staff did not become more efficient

using the equipment, nor did fish learn to avoid the electrical field between passes. To enable comparison of 2019 results with that of previous monitoring years, when different reach lengths may have been sampled, results were standardized to catch per meter.

3. Results and Discussion

3.1 Guadalupe River

Sampling occurred at six stations on the Guadalupe River on October 29 and 30, 2019. The weather was sunny and clear with no precipitation. Flows at the United States Geological Survey (USGS) gage upstream of Highway 101 (USGS #11169025), which provides the best representation of the juvenile rearing stations GR001, GR002, and GR003, were approximately 35.0 cubic feet per second (cfs; flow measurements will be reported using the standard unit system) during all sampling days. Stations located upstream of Los Gatos Creek (GR004, GR005, and GR006) will have flow lower than what occurs at Highway 101. The nearest gage to these sampling locations is ALERT 5023 Guadalupe River above Almaden Expressway, and had flows approximately at 9.0 cfs.

GR001

This was the most downstream station sampled on the Guadalupe River and was one of the stations that had been sampled during the 2004-2018 monitoring effort. This station is low gradient. A dense riparian corridor is present (Figure 6), but the channel is situated between two levees and urban development. The monitoring station was 40.0 m in length with an average wetted width of 8.5 m and an average depth of 0.5 m. Three habitat types were present within the station: riffle, run, and pool. Riffle habitat made up 75% of the habitat sampled, with run contributing to 25%. The pool habitat was a side channel pool that branched from the riffle crest. The pool habitat was not included in the areas analysis as it was not part of the total length of the sampling reach. The primary substrate was cobble with a secondary substrate of gravel. Water quality and habitat complexity at the time of sampling are summarized in Table 4.



Figure 6: Photos of station GR001, looking upstream (left) and looking downstream (right).

Table 4: Guadalupe River station GR001 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
816.00	15.67	6.83	30.00

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	0	1	1	3	2	0

Tandem electrofishers were used at this site. Fish captured and associated population estimates are summarized in Table 5. Five species of fish were captured: prickly sculpin (*Cottus asper*), Sacramento sucker (*Catostomus occidantalis*), California roach (*Lavinia symmetricus*), mosquitofish (*Gambusia affinis*), and largemouth bass (Micropterus salmoides). The most abundant species was prickly sculpin (n=161). No *O. mykiss* were captured.

Table 5: Number captured and population estimates at station GR001 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	1	1	2.03	1-1
Largemouth bass	No	1	1	0.73	1-1
Mosquitofish	No	2	2	0.00	2-2
Prickly sculpin	Yes	161	290	70.52	161-429
Sacramento sucker	Yes	7	11	10.57	7-35

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR001 most abundant species was prickly sculpin and native fish made up the bulk of the fish captured, though three non-native fish were present. The MLIP population estimate indicates that the number prickly sculpin and Sacramento sucker is likely higher than what was observed.

Station GR001 has 15 years of comparable data (no sampling occurred in 2014). Figure 7 shows the standardized capture of *O. mykiss* between 2004 and 2019. This station historically has low production of *O. mykiss*: of the 15 years of data, *O. mykiss* were only collected in four of the years, and the highest capture rate (in 2005) was 0.10 fish per meter. *O. mykiss* have not been observed since 2012. The average *O. mykiss* capture rate for this station is 0.015 fish per meter. These results indicate that *O. mykiss* occurrence in this downstream portion of the Guadalupe River is very low, inconsistent, and potentially that recolonization has not occurred after the severe drought conditions that occurred in 2014-2016.

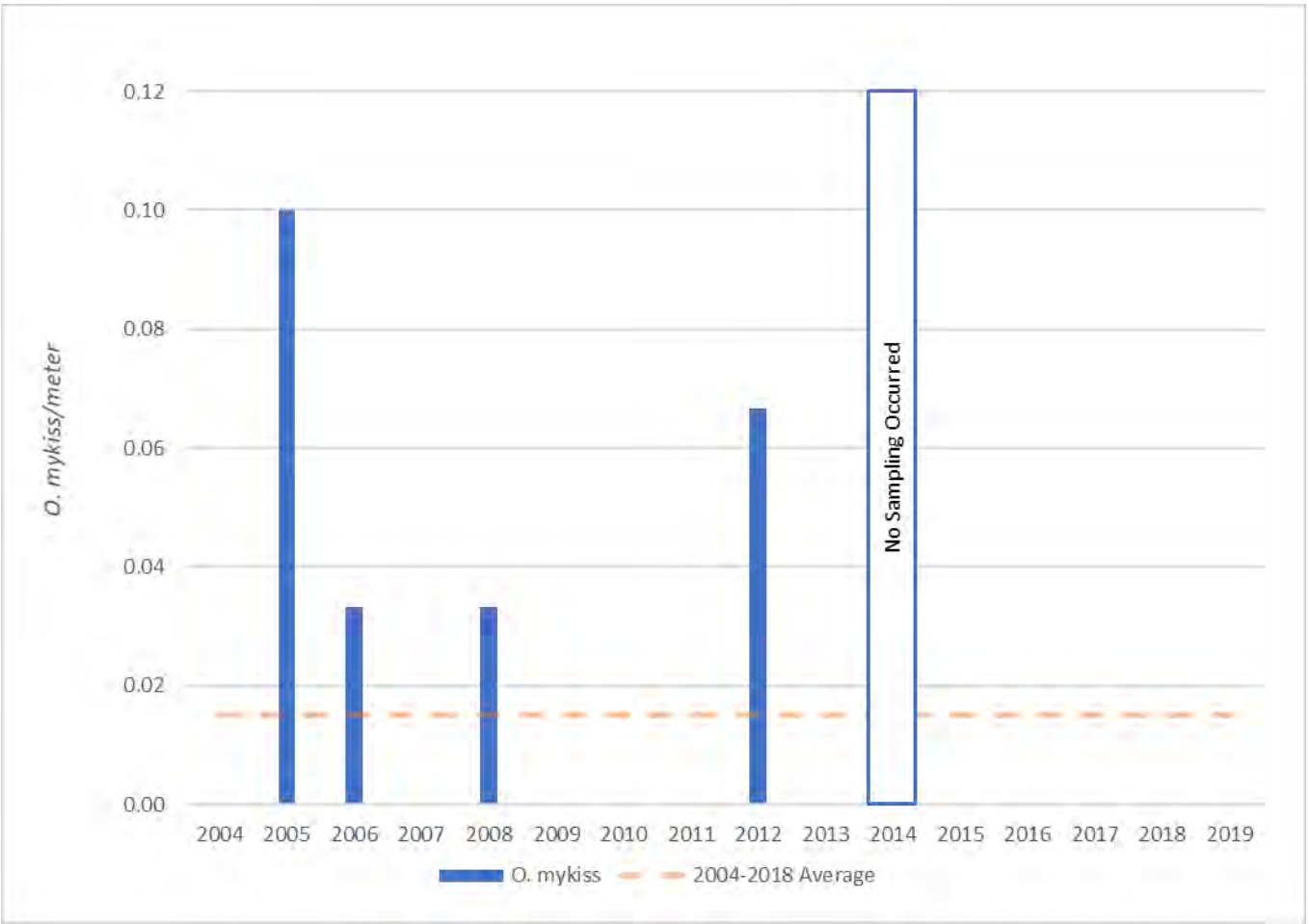


Figure 7: Station GR001 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GR002

This station was a continued sampling location from the 2004-2018 sampling period. This station is bordered by the Guadalupe Park and Gardens and Highway 87. A dense riparian corridor is present, but there is a high level of anthropogenic disturbances (homeless, trash and debris). The monitoring station was only 35.0 m in length (rather than 40.0 m) due to a pool at the downstream end and portions of the run on the upstream end that were too deep to sample. This is consistent with the 2018 sampling event. The average wetted width was 8.5 m and the average depth was 0.5 m. Two habitat types were present within the station: riffle and run (Figure 8). The riffle habitat was 69% of the reach; run habitat was 31%. The primary substrate was large cobble

with a secondary substrate of gravel. Water quality and habitat complexity at the time of sampling is summarized in Table 6.



Figure 8: Photos of station GR002, looking upstream (left) and looking downstream (right).

Table 6: Guadalupe River station GR002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
697.00	14.17	6.95		30.00		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	4	2	1	2	2	0

Tandem electrofishers were used at this site. Prickly sculpin, Sacramento sucker, and California roach (all native) were collected. Fish captured and associated population estimates are summarized in Table 7. The MLIP indicates that the number of California roach is likely higher than what was observed. No *O. mykiss* were captured at this monitoring station.

Station GR002 has 13 years of comparable data (drought conditions in 2014-2015 and higher than normal flows in 2017 precluded sampling at this station in those years). Figure 9 shows the standardized capture of *O. mykiss* between 2004 and 2019. *O. mykiss* were collected in eight of the 13 years of data, and the highest fish per meter observed was in 2008 at 0.60 fish. The average *O. mykiss* per meter (*O. mykiss/m)* based on the 2004-2018 sampling period was 0.13 fish. Previous sampling results indicate that juvenile *O. mykiss* used this site in most years. Current results indicate that rearing in this portion of the Guadalupe River is extremely low or recolonization has not occurred after the drought conditions (including dry-backs) starting in 2014.

Table 7: Number captured and population estimates at station GR002 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	20	25	6.63	20-39
Prickly sculpin	Yes	21	21	1.16	21-23
Sacramento sucker	Yes	7	7	0.12	7-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

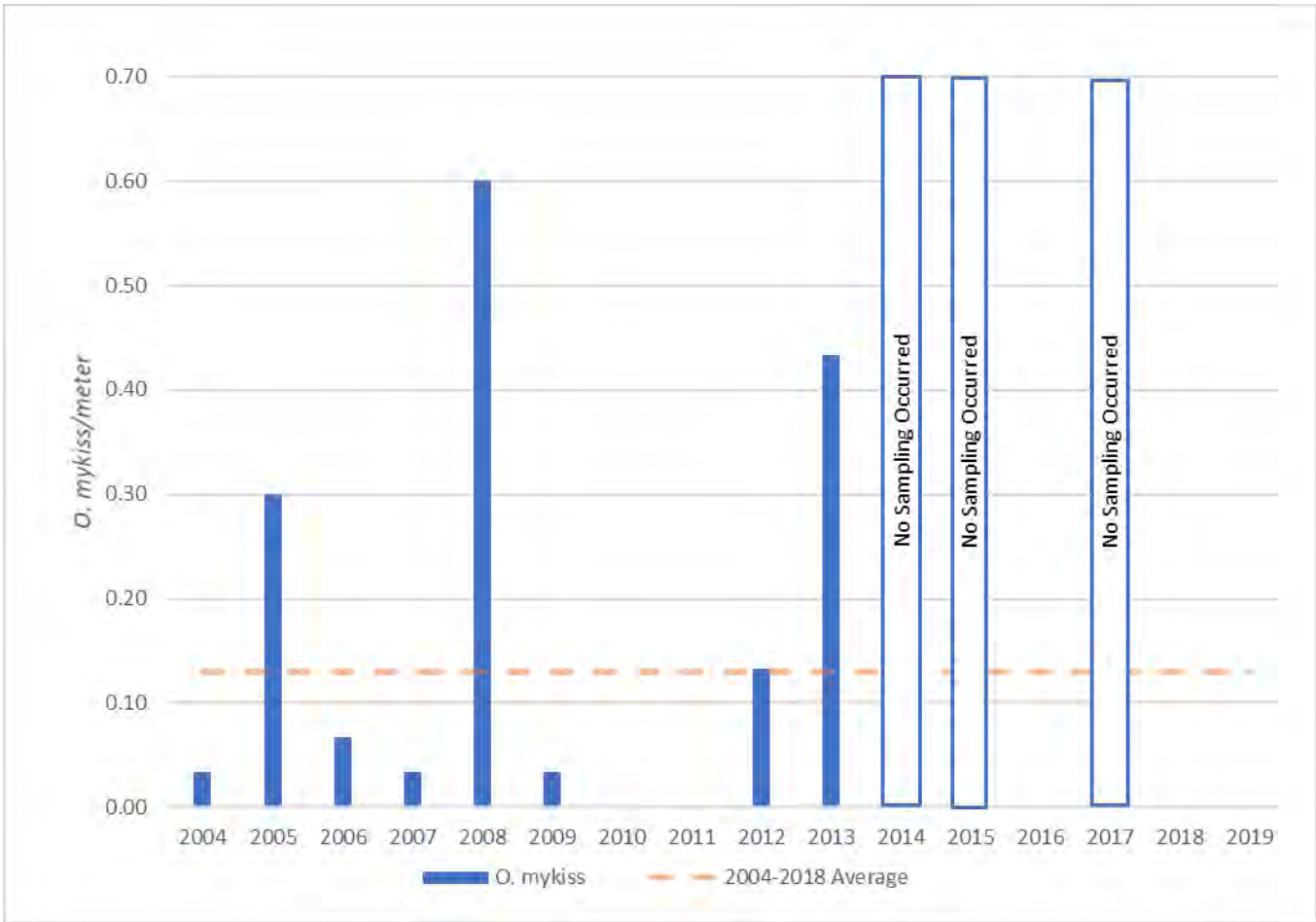


Figure 9: Station GR002 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GR003

This station was a continued sampling location previously sampled 2004-2018. This station includes the St. John Street passage remediation project, which created riffle habitat and added large woody debris to remove a fish passage barrier. A portion of the station was under the St. John Street Bridge. The monitoring station was 40.0 m in length with an average wetted width of 9.0 m and an average depth of 0.35 m. Two habitat types were present within the station: riffle and run (Figure 10). Each made up 50% of the station. The primary substrate was large cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 8.



Figure 10: Photos of station GR003, looking upstream (left) and looking downstream (right).

Table 8: Guadalupe River station GR003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
648	14.19	7.02	30.7

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	4	1	0	2	0	4*

*Artificial structures in this reach include the design riffle and installed large woody debris.

Tandem electrofishers were used at this site. The four species of fish captured were: *O. mykiss,* California roach, prickly sculpin, and Sacramento sucker. The most abundant species encountered was California roach (n=41). Fish captured and associated population estimates are summarized in Table 9. One *O. mykiss* was captured in this reach (Figure 11).

Table 9: Number captured and population estimates at station GR003 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	69	89	13.50	69-116
Prickly sculpin	Yes	17	24	10.36	17-45
O. mykiss	Yes	1	1	0.73	1-1
Sacramento sucker	Yes	5	5	1.19	5-8

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval



Figure 11: *O. mykiss* captured at GR003 in recovery live car prior to release.

The MLIP indicates that the number of California roach and prickly sculpin is likely higher than what was captured. One *O. mykiss* was captured, and it measured 248 mm. Based on the size range, the fish is likely in its second year, and is showing signs of smoltification. This fish was captured on the second pass of electrofishing indicating it was missed on the first pass. It is likely that more fish are present, but due to the width and velocity in the reach they may have avoided capture.

Station GR003 has 14 years of comparable data (drought conditions precluded sampling at this station in 2014-2015). Figure 12 shows the standardized capture of *O. mykiss* between 2004 and 2019. Of the 14 years of data, *O. mykiss* were collected in eight of the years sampled and the highest fish per meter observed was in 2012 at 0.43

fish. The average *O. mykiss*/m based on the 2004-2018 dataset for this station is 0.11 fish. The 2019 sampling is still below average, but this was the first year since 2013 that *O. mykiss* were captured. This is a positive as it shows rearing is still potentially occurring, though it is at a low rate. This could also be an indicator that recolonization after the drought conditions (including dry-backs) starting in 2014 is starting to occur.

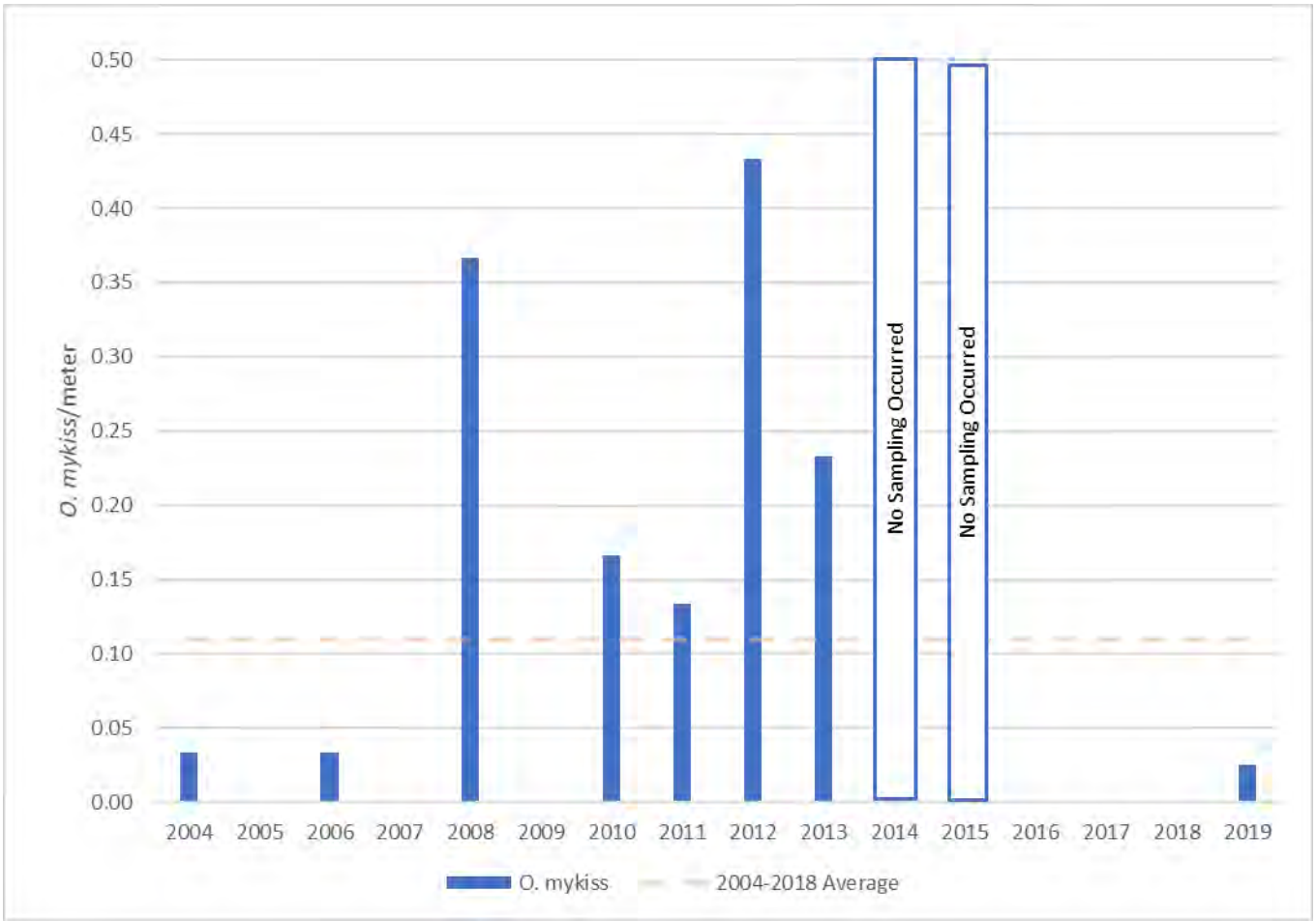


Figure 12: Station GR003 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GR004

This station was a continued sampling location from the 2004-2018 monitoring and falls within the Downtown Project's hardscaped reach. The channel bottom consists of cellular concrete mattress (CCM), with natural substrates deposited on the surface. The monitoring station was 40.0 m in length with an average wetted width of 3.0 m and an

average depth of 0.7 m. Habitat at the station was 88% glide and 12% riffle (Figure 13). The primary substrate was silt with a secondary substrate of boulders over the top of the CCM. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 10. Portion of the downstream end of the reach were densely covered in emergent vegetation.



Figure 13: Photos of station GR004, looking upstream (left) and looking downstream (right).

Table 10: Guadalupe River station GR004 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)
682.00	13.98	7.53	72.00

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
4	1	0	0	1	0	4

Two species of fish captured were: California roach and Sacramento sucker. The most abundant species encountered was California roach (n=25). Fish captured and associated population estimates are summarized in Table 11. The MLIP did not indicate

the calculated population estimate as higher than what was observed. All the species encountered were native. No *O. mykiss* were captured at this monitoring station.

Table 11: Number captured and population estimates at station GR004 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	25	25	0.99	25-27
Sacramento sucker	Yes	1	1	0.00	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GR004 has 14 years of comparable data. As at previous sites, drought induced dry-backs occurred in this reach in 2015. Figure 14 shows the standardized capture of *O. mykiss* between 2004 and 2019. This station historically has low occurrence of *O. mykiss*. Of the 13 years of data, only two years had collection of *O. mykiss* with the highest fish per meter observed in 2012 at 0.20 fish. The average *O. mykiss*/m based on the 2004-2018 dataset for this station is 0.028 fish. Results indicate that juvenile rearing in this portion of the Guadalupe River is historically extremely low.

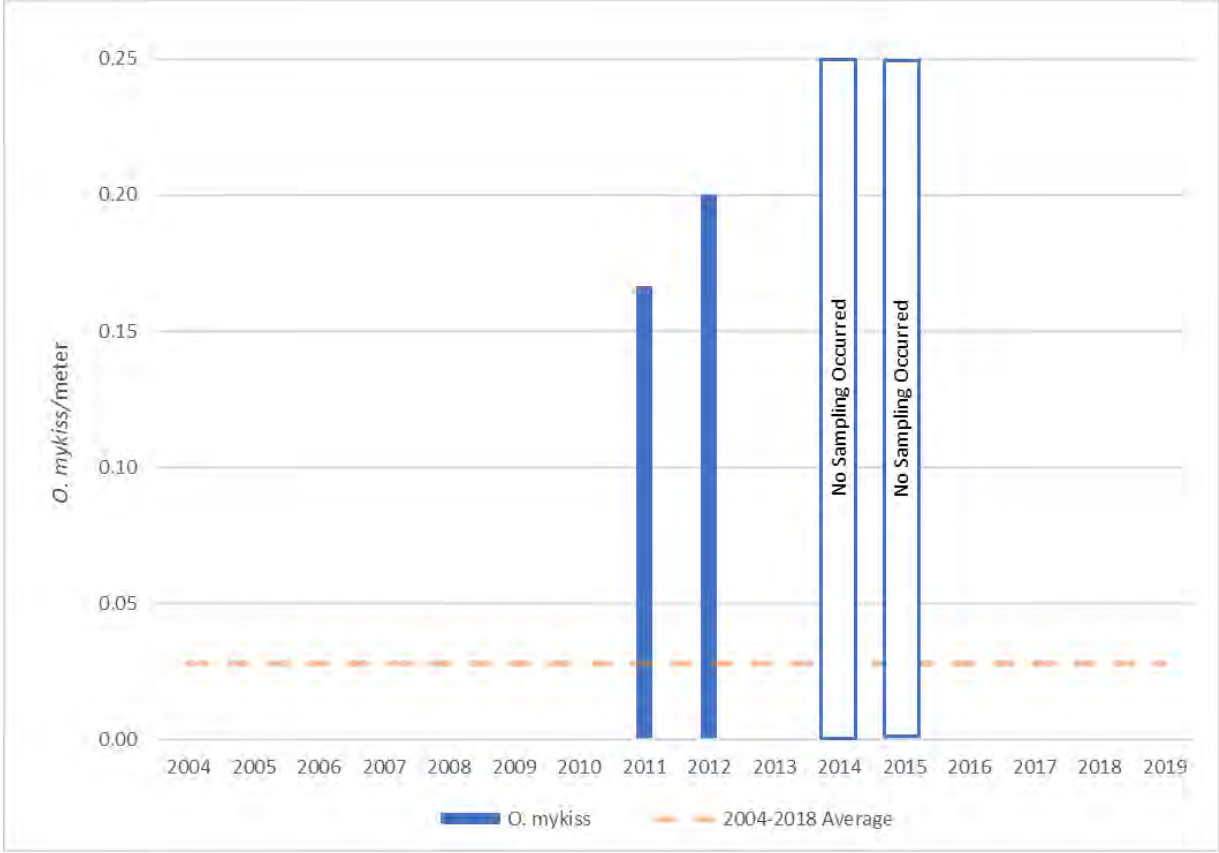


Figure 14: Station GR004 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GR005

This station was first sampled in 2018 and is directly downstream of the Virginia Street bridge. The monitoring station was 40.0 m in length with an average wetted width of 10.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and glide (Figure 15). The riffle portion of the habitat was short and had high gradient portions as a result of a removed unpermitted, human-made rock and rubble crossing placed in the creek. The crossing was removed by a volunteer group in fall 2018, but the results of the building is still present. Homeless camps were present in the area. The riffle made up 38% of the habitat with the glide making up the remaining 62%. The primary substrate was silt with a secondary substrate of boulders. A cement wall, which is a portion of the bridge abutment, goes along the entire east bank of the monitoring station. Results of the water quality monitoring and the ocular assessment of

habitat complexity can be seen in Table 12. Issues with the water quality instrumentation calibration led to turbidity not being able to be collected.



Figure 15: Photos of station GR005, looking upstream (left) and looking downstream (right).

Table 12: Guadalupe River station GR005 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
693	13.54	6.97	-

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	3	0	2	1	1	3

Tandem electrofishers were used at this station. A total of three species of fish were captured: California roach, green sunfish, and mosquitofish. The most abundant species encountered was California roach (n=20). The overall assemblage of fish declined in 2019, with seven species being captured in 2018. Fewer non-native fish species were captured in 2019, but still non-native fish were present. Fish captured and associated population estimates are summarized in Table 13. No *O. mykiss* were captured at this

monitoring station. In station GR005 the MLIP indicate that the number of California roach and mosquitofish was likely higher than what was captured.

Table 13: Number captured and population estimates at station GR005 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	20	24	5.27	20-35
Green sunfish	No	1	1	2.03	1-1
Mosquitofish	No	13	20	0.00	20-20

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

GR006

This station is the most upstream station on the mainstem Guadalupe River and was first sampled in 2018. The monitoring station was 40.0 m in length with an average wetted width of 8.0 m and an average depth of 0.15 m. Habitat at the station was 88% run and 12% riffle (Figure 16). Portions of the sampling reach were underneath the Almaden Expressway northbound overcrossing. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 14.



Figure 16: Photos of station GR006, looking upstream (left) and looking downstream (right).

Table 14: Guadalupe River station GR006 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
522.00	13.36	5.78		11.90		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
4	3	0	0	1	0	1

Tandem electrofishers were used at this station. Five species of fish were captured: Sacramento sucker, California roach, largemouth bass, spotted bass (*Micropterus punctulatus*) and mosquitofish. The most abundant species encountered was Sacramento sucker (n=119). Three non-native fish species were present with two being known predators of *O.* mykiss. Fish captured and associated population estimates are summarized in Table 15.

Table 15: Number captured and population estimates at station GR006 on the Guadalupe River.

Species	Native	n	N	SE	95% CI
California roach	Yes	6	6	1.00	6-9
Largemouth bass	No	5	6	3.57	5-15
Mosquitofish	No	1	1	0.73	1-1
Sacramento sucker	Yes	119	136	8.77	119-153
Spotted bass	No	1	1	2.03	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Guadalupe River Discussion

One *O. mykiss* was collected on the Guadalupe River in 2019. Five of the six stations did not yield detection of *O. mykiss*. Based on the previous Guadalupe River Project monitoring (WYs 2004-2018), it is not uncommon for this species to be absent or in low abundance at individual monitoring stations on the mainstem Guadalupe River. Since 2004, no monitoring station in the Guadalupe River has consistently had *O. mykiss*. The 2019 sampling effort is the first year yielding *O. mykiss* detections, since a four-year

span where no *O. mykiss* were detected. This is a positive development as it could be an indicator that recolonization is occurring after the extreme droughts starting in 2014.

Though juvenile *O. mykiss* were detected in Guadalupe River, the numbers are still below the average. There have been no detectable changes in physical habitat on the Guadalupe River that would trigger such a decrease. All stations sampled had some sort of habitat complexity (i.e., undercut banks, large woody debris, or submerged roots) that could be used as *O. mykiss* refugia, and riffle habitat that should support fast-water feeding requirements. The measurable objectives for streamside vegetation in the Downtown Project are being met, and other fisheries monitoring indicators, such as suitable habitat area, have indicated that habitat is available and consistent with unaltered index reaches (VALLEY WATER and Stillwater Sciences 2019). Previous MMRs have discussed the influence that sampling timing appears to have on the number of *O. mykiss* detected in mainstem Guadalupe River. In years that sampling occurred after a rain event, more *O. mykiss* were observed, but in each year between 2004-2013 fish were detected in a portion of the Guadalupe River (VALLEY WATER and Stillwater Sciences 2013). In 2019 sampling occurred after a chance storm in September 2019, that raised the Guadalupe River to approximately 100 cfs. The capture of the *O. mykiss* on the Guadalupe River could be a result of this storm and supports the hypothesis that the Guadalupe River is not a primary producer of *O. mykiss*, or preferred area of summer rearing, but rather serves as a migration corridor, winter rearing, and smoltification habitat.

Efforts in 2019, continue to show patterns in the capture of native fish that add to the evidence that fish populations have not rebounded after the severe drought conditions in 2014-2016. Prior to 2014, the average annual catch of all native fish in the four consistently sampled stations was 4.48 fish per meter (California roach were particularly plentiful). In 2015 and 2016, some stations yielded zero fish or were completely dry. From 2015 to 2018 the average annual catch was 0.56 fish per meter. In 2019 the average density of native fish at the four repeated stations was 2.16 fish per meter. This is higher than the post-drought average, but still approximately half of what was

observed between 2004-2013. Observing *O. mykiss* and seeing an increase density of native fish is a positive sign, but it appears populations have not fully rebounded after the drought.

3.2 Guadalupe Creek

Sampling occurred at six stations on Guadalupe Creek on October 9 and 10, 2019. All sampling days were sunny and clear. Flows at the four stations upstream of Masson Dam on Guadalupe Creek (GR003 – GR006), based on ALERT Gage 5017 Guadalupe Creek below Guadalupe Reservoir, were between 5.6 and 7.5 cfs. Flows at the two stations downstream of Masson Dam (GC001 and GC002), based on ALERT gage 5114 Masson Fish Ladder- Low Flow Only, were between 3.8 and 5.2 cfs.

GC001

This was the most downstream station sampled and was monitored during the 2004-2018 monitoring period. This monitoring station is surrounded by urban residential housing and falls within a mitigation reach for the Downtown Project, where extensive geomorphic and riparian restoration occurred. The restoration was completed in 2002. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.20 m. Three habitat types were present within the station: riffle, run, and pool (Figure 17). Run habitat made up 43% of the sampled area, followed by riffle habitat at 38% with pool habitat making up the remaining 19%. The primary substrate was gravel with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 16.



Figure 17: Photos of station GC001, looking upstream (left) and looking downstream (right).

Table 16: Station GC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
414.00	15.89	8.56	20.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	1	1	1	3	2	0

Four species of fish were captured during the survey: *O. mykiss,* prickly sculpin, California roach, and Sacramento sucker. The most abundant species encountered was California roach (n=23). Four *O. mykiss* were captured and PIT tagged during the sampling effort. Fish captured and associated population estimates are summarized in Table 17. The MLIP indicates that the number of California roach and Sacramento sucker is likely higher than what was captured.

Table 17: Number captured and population estimates at station GC001 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	23	25	3.00	23-31
Prickly sculpin	Yes	8	8	1.06	8-10
O. mykiss	Yes	4	4	0.00	4-4
Sacramento sucker	Yes	4	8	17.59	4-50

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC001 has 14 years of comparable data. No data was collected in this reach in 2015 due to drought-induced drybacks. Figure 18 shows the standardized capture of *O. mykiss* between 2004 and 2019. In most years *O. mykiss* were captured at this station. The highest capture rate occurred in 2006 at 0.20 *O. mykiss*/m. The average *O. mykiss* density at this site between 2004-2018 (excluding years when no sampling occurred) was 0.05 *O. mykiss*/m. The density during the 2019 monitoring was 0.10 *O. mykiss*/m. This is above the average from previous years' data collection efforts and an increase from 2018. Results indicate that juvenile rearing in this portion of Guadalupe Creek is variable, but *O. mykiss* have consistently utilized this habitat since 2017 after 2014 drought conditions and dry-backs of 2015. A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

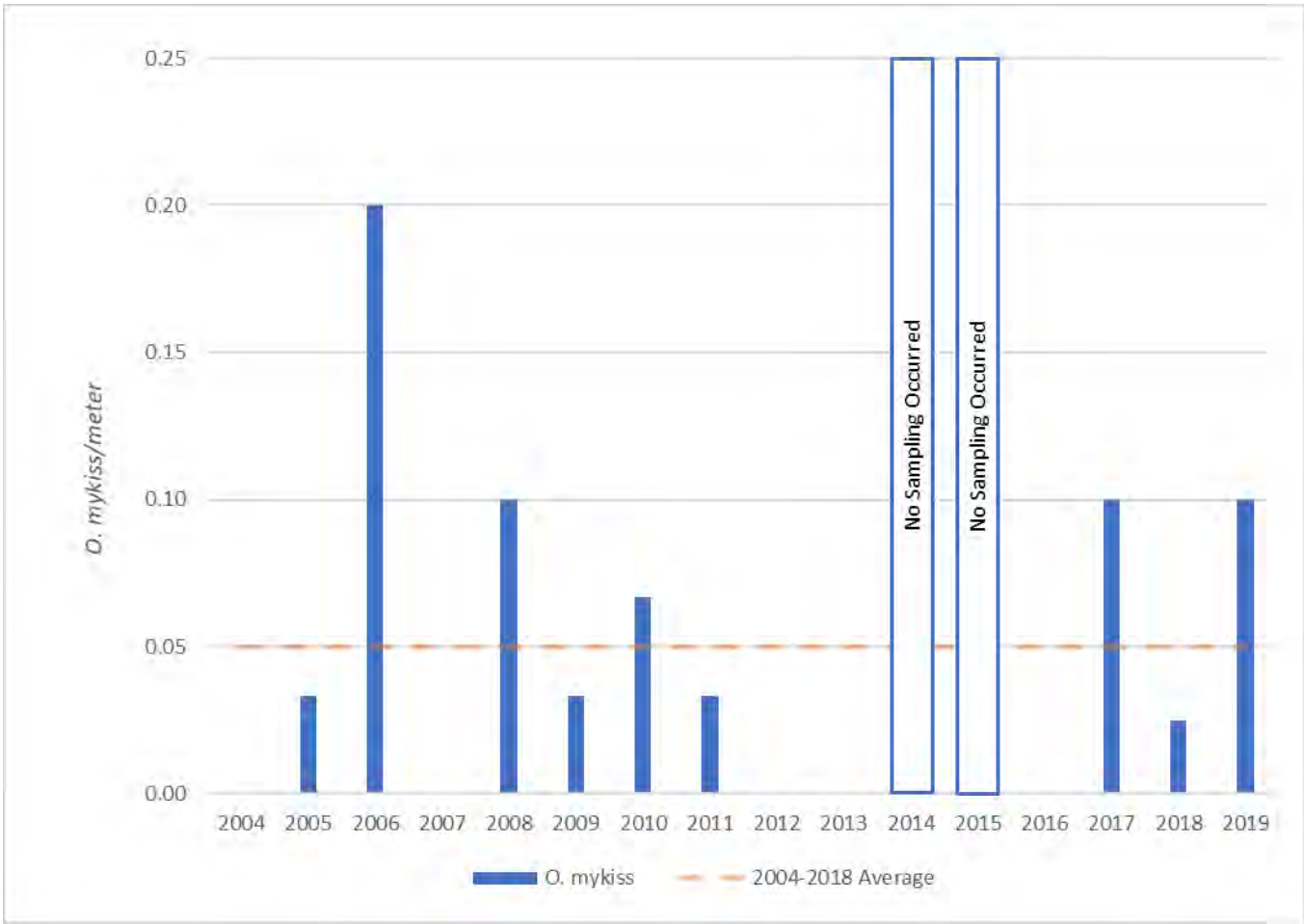


Figure 18: Station GC001 (previously station 14) standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this Station.

GC002

This station was sampled during the previous monitoring effort in 2004-2018. The station is also within the mitigation reach for the Downtown Project. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.2 m. Three habitat types were present within the station: run, riffle, and pool (Figure 19). The run habitat made up 13%, the riffle 62%, and the pool the remaining 25%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 18. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.



Figure 19: Photos of station GC002, looking upstream (left) and looking downstream (right).

Table 18: Station GC002 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
438.00	16.44	-	12.80

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	0	1	1	3	1	0

Four species of fish were captured during the survey: *O. mykiss*, riffle sculpin, Sacramento sucker, and California roach. The most abundant species encountered was riffle sculpin (n=143). The MLIP indicated the number of California roach, Sacramento sucker, and riffle sculpin were likely higher than what was captured. Three *O. mykiss* were captured during the sampling effort and were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 19.

Table 19: Number captured and population estimates at station GC002 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	34	38	4.33	34-47
O. mykiss	Yes	3	3	1.27	3-8
Riffle sculpin	Yes	143	162	8.96	144-180
Sacramento sucker	Yes	12	19	13.53	12-47

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC002 has 14 years of comparable data. No data was collected in this reach in 2014 and 2015 due to drought-induced drybacks. Figure 20 shows the standardized capture of *O. mykiss* between 2004 and 2019. In most years *O. mykiss* were captured at this station. The highest capture rate was 0.10 *O. mykiss*, and occurred in years 2005, 2010, and 2017. The average *O. mykiss* density at this site between 2004-2018 (excluding years when no sampling occurred) was 0.04 fish per meter. The density during the 2019 monitoring was 0.075 *O. mykiss*/m. Results indicate that juvenile rearing in this portion of Guadalupe Creek is variable, and 2019 had higher than average densities. This was the only station on Guadalupe Creek to have detections of *O. mykiss* in 2016 and has continued to support above average densities post 2014 drought and drybacks of 2015. A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

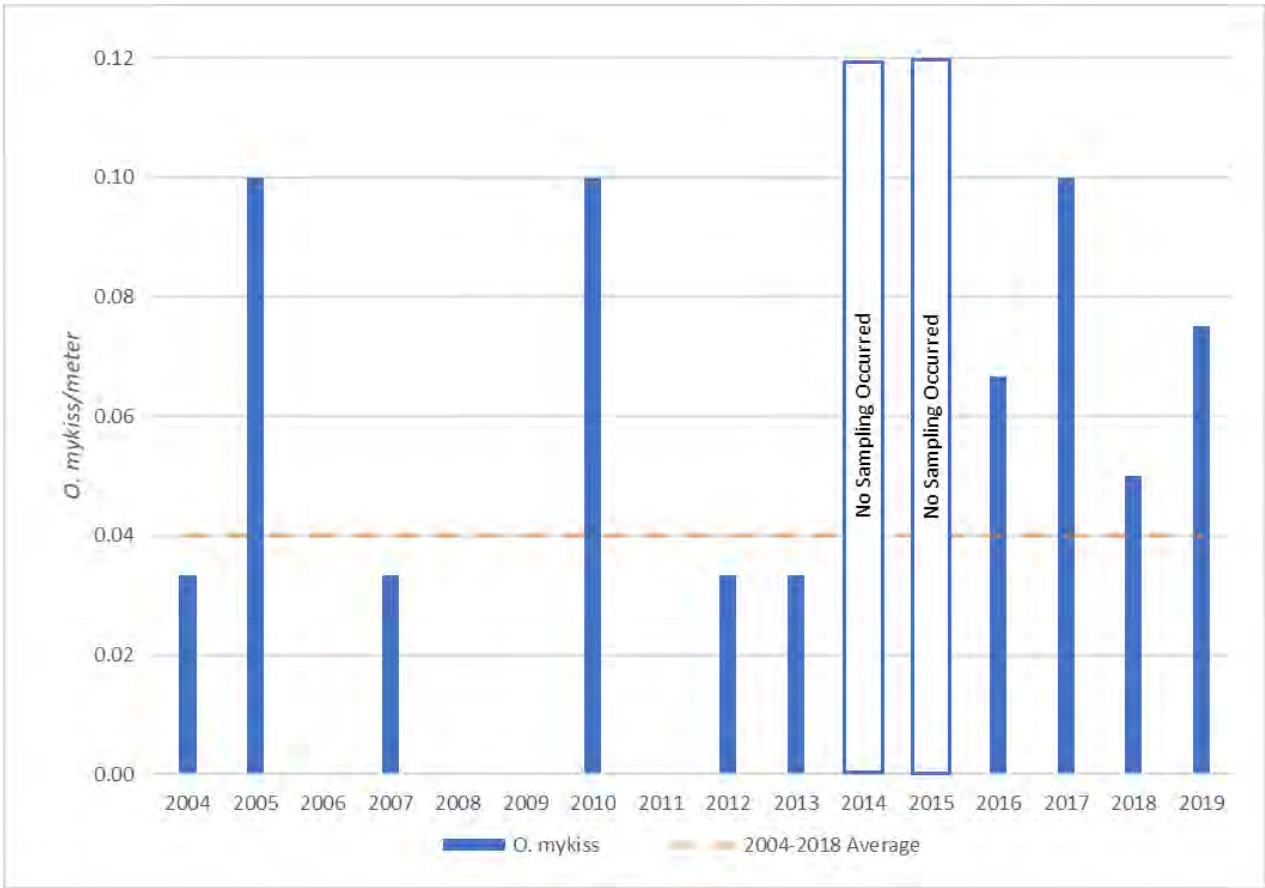


Figure 20: Station GC002 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GC003

This station was sampled during the previous monitoring effort in 2004-2018. The station is upstream of Masson Dam, and is in an urban residential area. The monitoring station was 40.0 m in length with an average wetted width of 5.0 m and an average depth of 0.35 m. Three habitat types were present within the station: riffle, run, and glide (Figure 21). Habitat at the station was 40% riffle, 35% run, and 25% glide. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 20.



Figure 21: Photos of station GC003, looking upstream (left) and looking downstream (right).

Table 20: Station GC003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
408.00	14.81	8.40	27.40

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	2	1	1	3	4	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, riffle sculpin, and Sacramento sucker. The most abundant species encountered was riffle sculpin (n=143). Seven *O. mykiss* were captured during the sampling effort, six of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 21.

In station GC003 the MLIP indicates that the number of California roach and riffle sculpin are likely higher than what was captured. The MLIP did not indicate that the *O. mykiss* population was higher than observed. All the fish captured in the reach were native.

Table 21: Numbered captured and population estimates at station GC003 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	27	31	4.76	27-41
O. mykiss	Yes	7	7	0.58	7-8
Riffle sculpin	Yes	143	170	12.41	146-194
Sacramento sucker	Yes	2	2	0.38	2-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC003 now has 15 years of comparable data. Figure 22 shows the standardized capture of *O. mykiss* between 2004 and 2019. No sampling occurred in 2014 due to drought conditions. In all but four years, *O. mykiss* were captured at this station. This reach did not experience drybacks in 2015, but flow conditions were very low and no *O. mykiss* were captured in 2015 or 2016. In 2017 *O. mykiss* returned, but in low density. The average *O. mykiss* density at this site between 2004-2018 (excluding years when no sampling occurred) was 0.15 fish per meter. The 2018 sampling resulted in the highest observed capture rate at 0.83 fish per meter and an estimated density of 1.25 *O. mykiss*/m. In 2019 the observed and estimated density of *O. mykiss* was 0.18 fish per meter. This was lower than what was observed in 2018 but is above the 14 year average. Results indicate that 2018 may have been an outlier in terms of densities in the reach, but the station is still seeing above average densities. A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

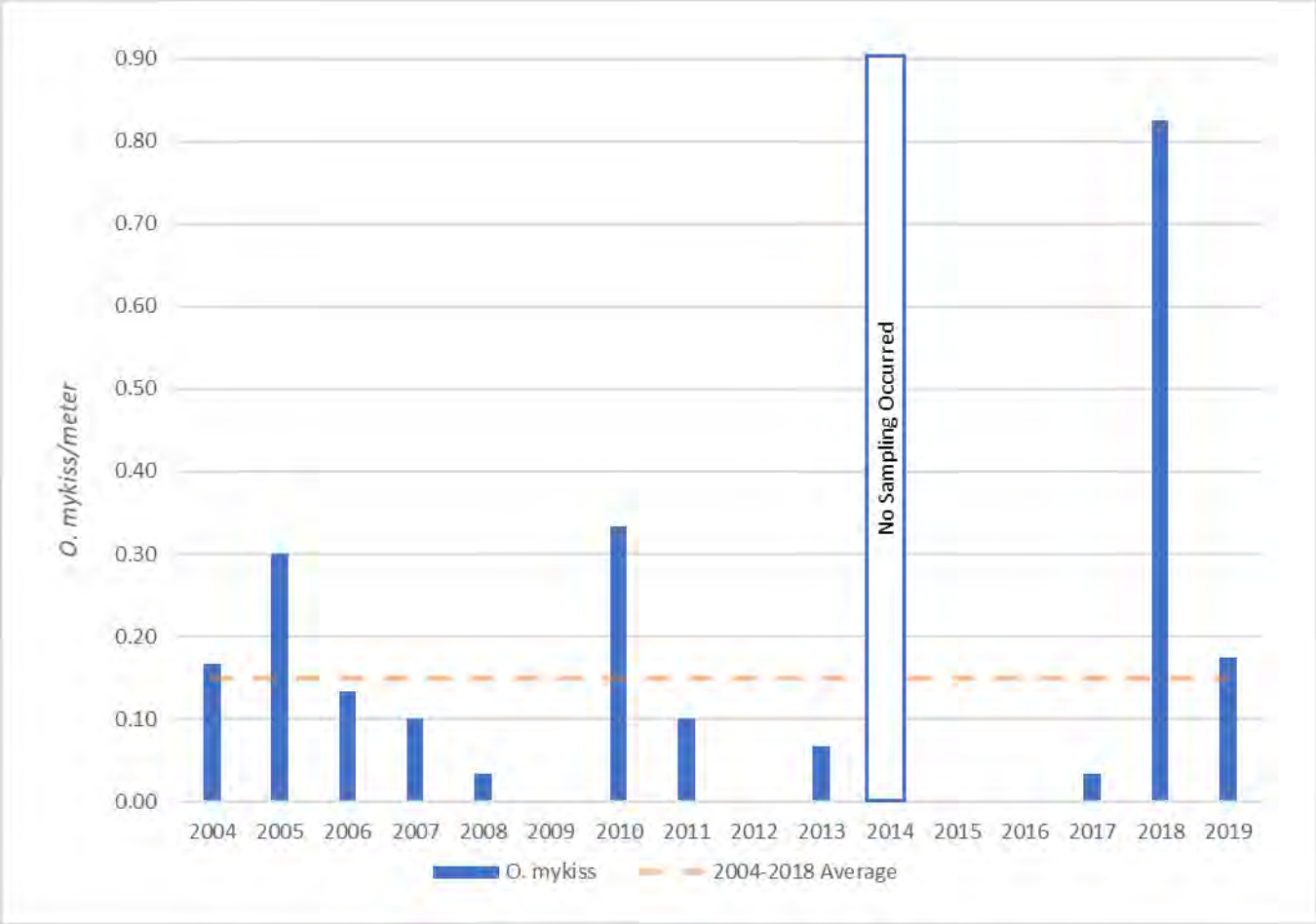


Figure 22: Station GC003 standardized *O. mykiss* capture 2004-2019. Dashed line indicates the average density from 2004-2018 from this station.

GC004

This station was sampled during the previous monitoring effort between 2004 and 2018. The station is situated amongst rural residential areas. The monitoring station was 40.0 m in length with an average wetted width of 5.5 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and cascade (Figure 23). Habitat at the station was 38% riffle, 60% run, and 2% cascade. The cascade habitat was a result of a debris and boulders creating a short, high gradient drop. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 22.



Figure 23: Photos of station GC004, looking upstream (left) and looking downstream (right).

Table 22: Station GC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**		**Turbidity (NTU)**		
404.00	14.90	8.37		49.00		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	2	1	3	3	2	0

Three species of fish were captured during the survey: *O. mykiss*, California roach, and riffle sculpin. The most abundant species encountered was riffle sculpin (n=160). Eight *O. mykiss* were captured during the sampling effort, seven of which were ≥65 mm so they were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 23.

Table 23: Number captured and population estimates at station GC004 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	10	49	226.78	10-505
O. mykiss	Yes	8	32	128.97	8-295
Riffle sculpin	Yes	160	190	12.99	164-216

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC004 has 15 years of comparable data. Figure 24 shows the standardized capture of *O. mykiss* between 2004 and 2019. In all but three years, *O. mykiss* were captured at this station. This reach did not experience drybacks in 2015, but flow conditions were very low and no *O. mykiss* were captured in 2015 or 2016. In 2017 *O. mykiss* returned. The highest density of *O. mykiss* occurred in 2005 at 1.03 fish per meter. This was the highest density recorded at any station during the entire 15-year monitoring period. The average *O. mykiss* density at this site between 2004-2018 was 0.43 fish per meter. The density during the 2019 monitoring was lower than the average from previous years' data collection efforts at 0.20 *O. mykiss*/m, and this station has seen below average results during the last seven sampling years. The density observed in 2019 was the same as in 2018, so no evidence of a decline is present in the short term. The MLIP predicted *O. mykiss* populations at 32 individuals, providing a predicted density of 0.80 *O. mykiss*/m, which is above the station average. The standard error and confidence intervals associated with this data are high because the lowest number of fish captured occurred on the first pass. Though the observed densities are below average, recolonization occurred after the 2014 drought conditions and levels appear to be consistent with last year's sampling effort and the reach still appears to consistently support rearing. Based on the population estimates it is likely more fish were present in the reach, but the analysis provides little confidence in delivering an accurate estimate. A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

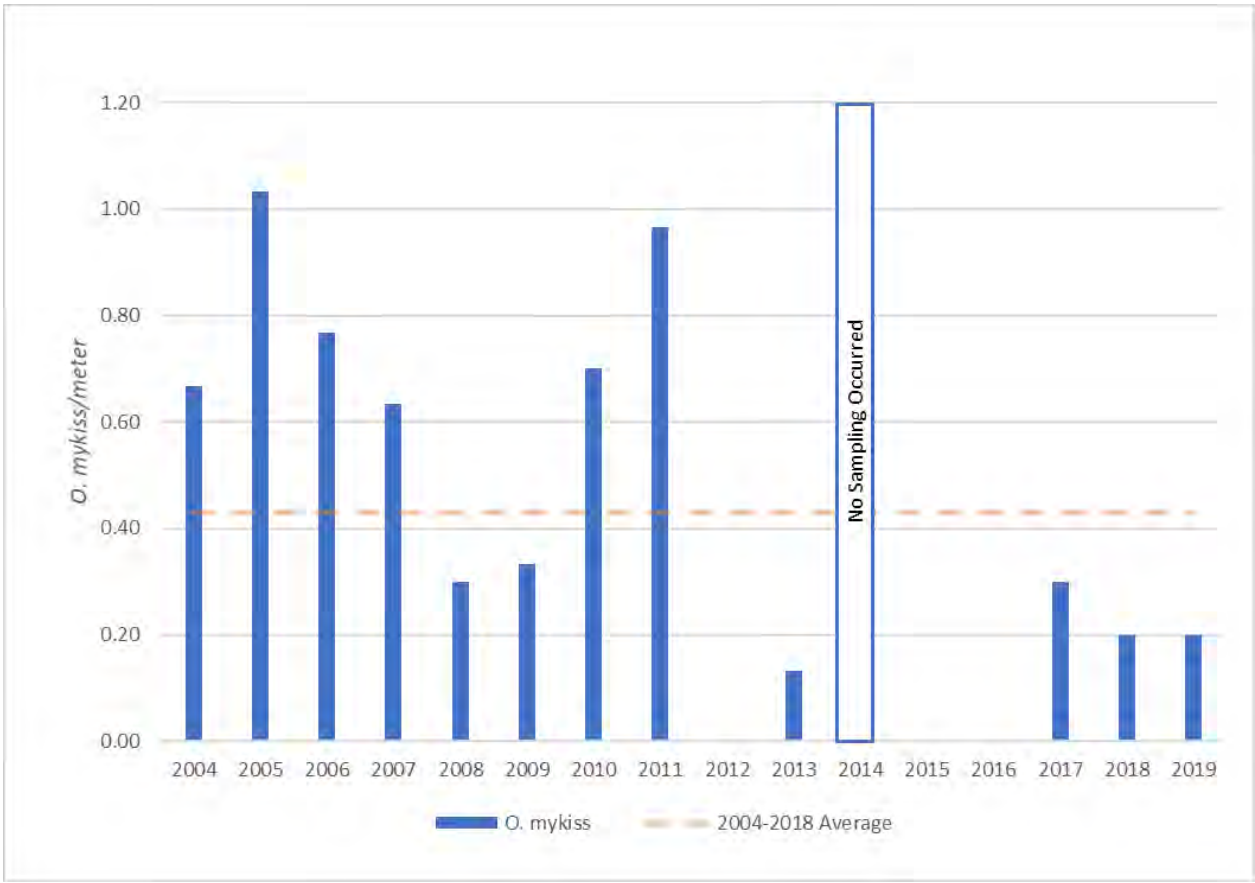


Figure 24: Station GC004 standardized *O. mykiss* capture 2004-201. Dashed line indicates the average density from 2004-2018 from this station.

GC005

This station was part of the expanded monitoring effort started in 2018. This is only the second year of data collection at this station. The station is surrounded by limited residential housing, but land disturbance to the east is present. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.2 m. Two habitat types were present within the station: riffle and run (Figure 25). The habitat area was evenly split between riffle and run habitat. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 24. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.



Figure 25: Photos of station GC005, looking upstream (left) and looking downstream (right).

Table 24: Station GC005 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
433.00	16.80	-	52.00

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
0	2	0	2	3	2	0

Three species of fish were captured during the survey: *O. mykiss*, riffle sculpin, and Sacramento sucker. The most abundant species encountered was riffle sculpin (n=45). Eight *O. mykiss* were captured during the sampling effort, 7 of which were ≥65 mm and were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 25. In station GC005 the MLIP indicates that the number of riffle sculpin is likely higher than what was captured.

Table 25: Number captured and population estimates at station GC005 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	8	8	0.51	8-9
Riffle sculpin	Yes	45	163	8.54	146-180
Sacramento sucker	Yes	2	2	0.38	2-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

A lower density of *O. mykiss* was captured in 2019 compared to 2018. This station had an observed and estimated density of 0.20 *O. mykiss*/m. Though lower densities were observed in 2019, this station was above the long-term average for Guadalupe Creek (Figure 26). A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

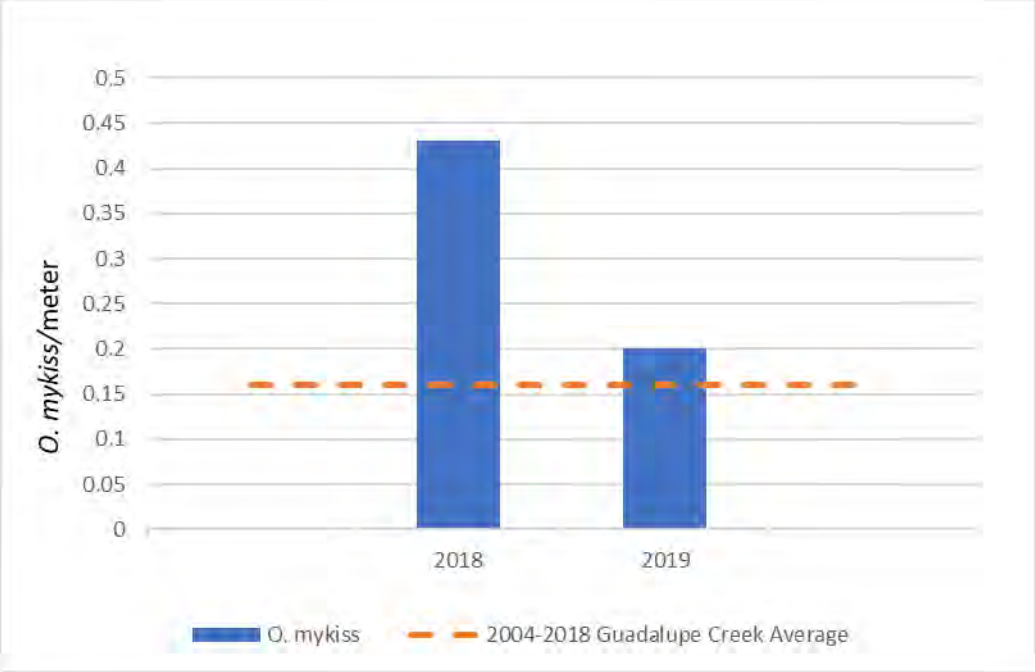


Figure 26: Station GC005 standardized *O. mykiss* capture 2018 and 2019. Dashed line indicates the average density from 2004-2018 for the Guadalupe Creek sub-Watershed.

GC006

This station was part of the expanded monitoring effort started in 2018. The station is surrounded by limited rural residential housing and was the most upstream station sampled. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.3 m. Four habitat types were present within the station: riffle, run, glide, and pool (Figure 27). The riffle habitat made up 15%, the run 38%, glide 33%, and the pool the remaining 14%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 26. Issues with the water quality instrumentation calibration lead to dissolved oxygen not being collected.



Figure 27: Photos of station GC006, looking upstream (left) and looking downstream (right).

Table 26: Station GC006 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
415.00	17.30	-	51.00

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	1	1	2	4	2	0

Two species of fish were captured during the survey: *O. mykiss* and riffle sculpin. The most abundant species encountered was riffle sculpin (n=49). Four *O. mykiss* were captured during the sampling effort, 2 of which were ≥65 mm and were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 27. The MLIP provided a population estimate higher than what was observed.

Table 27: Number captured and population estimates at station GC006 on Guadalupe Creek.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	4	8	17.59	4-50
Riffle sculpin	Yes	49	61	9.64	49-80

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

This was the second year of sampling at this station so no long-term comparisons over time can be made, but the 2019 results for this station were lower than what was observed in 2018. This station had an observed density (based on n) of 0.10 *O. mykiss*/m with a predicted density (based on N) of 0.20 *O. mykiss/*m. In 2018 the predicted and observed density was 0.13 *O. mykiss/*m. This was not a large deviation from the previous year, and if the predicted density is considered, it was above what was observed last year. The standard error and confidence intervals associated with the population prediction does not provide high confidence in the analysis. The average *O. mykiss* density from the 2004-2018 sampling period for repeated Guadalupe Creek stations is 0.16 *O. mykiss*/m. This station had an observed density below the long-term average for Guadalupe Creek in both years, but still supported *O. mykiss* (Figure 28). A more detailed analysis of *O. mykiss* capture data is provided in the Guadalupe Creek Discussion section later in the document.

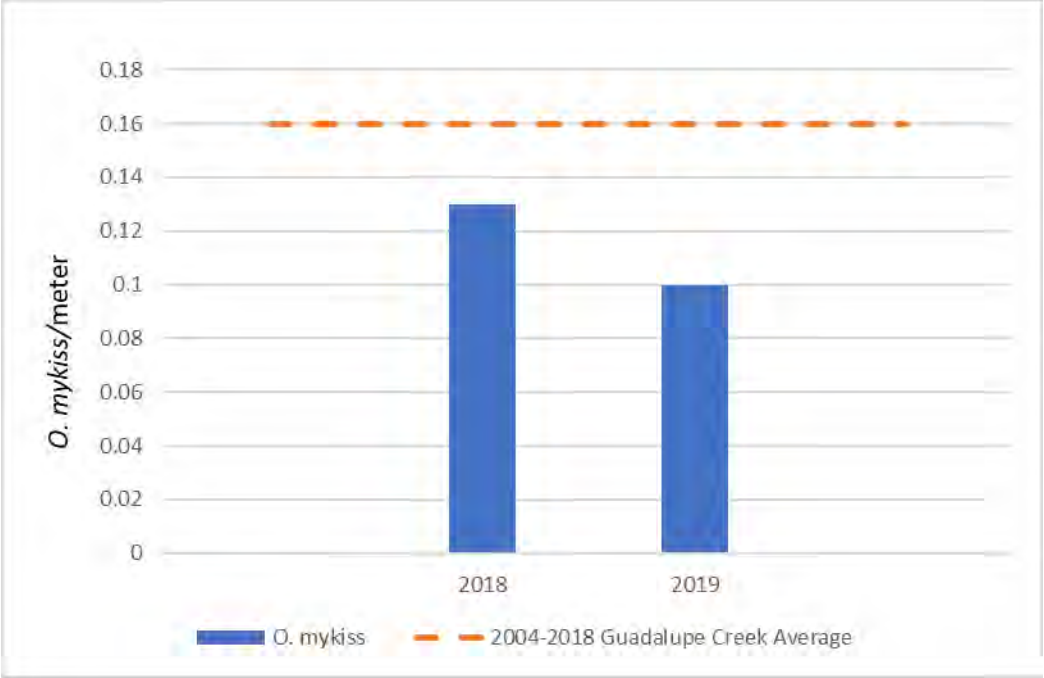


Figure 28: Station GC006 standardized *O. mykiss* capture 2018 and 2019. Dashed line indicates the average density from 2004-2018 for the Guadalupe Creek sub-Watershed.

Guadalupe Creek Discussion

Based on the results of the WY 2019 sampling, Guadalupe Creek continues to support rearing of *O. mykiss*. A total of 34 *O. mykiss* were collected in the six monitoring stations. MLIP analysis indicates that the number of *O. mykiss* present could have been as high as 62 individuals. Fork-lengths ranged from 60 mm to 234 mm (Figure 29). Growth rates of juvenile *O. mykiss* in California are highly variable and are dependent on temperature, food availability, seasonal flow, and population densities/competition (Moyle 2002). According to Moyle (2002), in small streams with low summer flows, such as the Guadalupe Creek, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith and Leicester (2016) aged 32 fish from Guadalupe Creek and found that young-of-the-year *O. mykiss* ranged from 85–114 mm, and fish in their second year ranged from 110–195 mm. This is a faster growth rate than predicted by Moyle (2002), but this is expected in warmer, more productive systems. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, *O. mykiss* captured in Guadalupe Creek in WY 2019 were predominantly young-

of-the-year, with some that had been through a second summer, and one fish that may have been it its third year. The abundance of young-of-the-year fish observed indicates that Guadalupe Creek had successful reproduction and summer rearing in 2019.

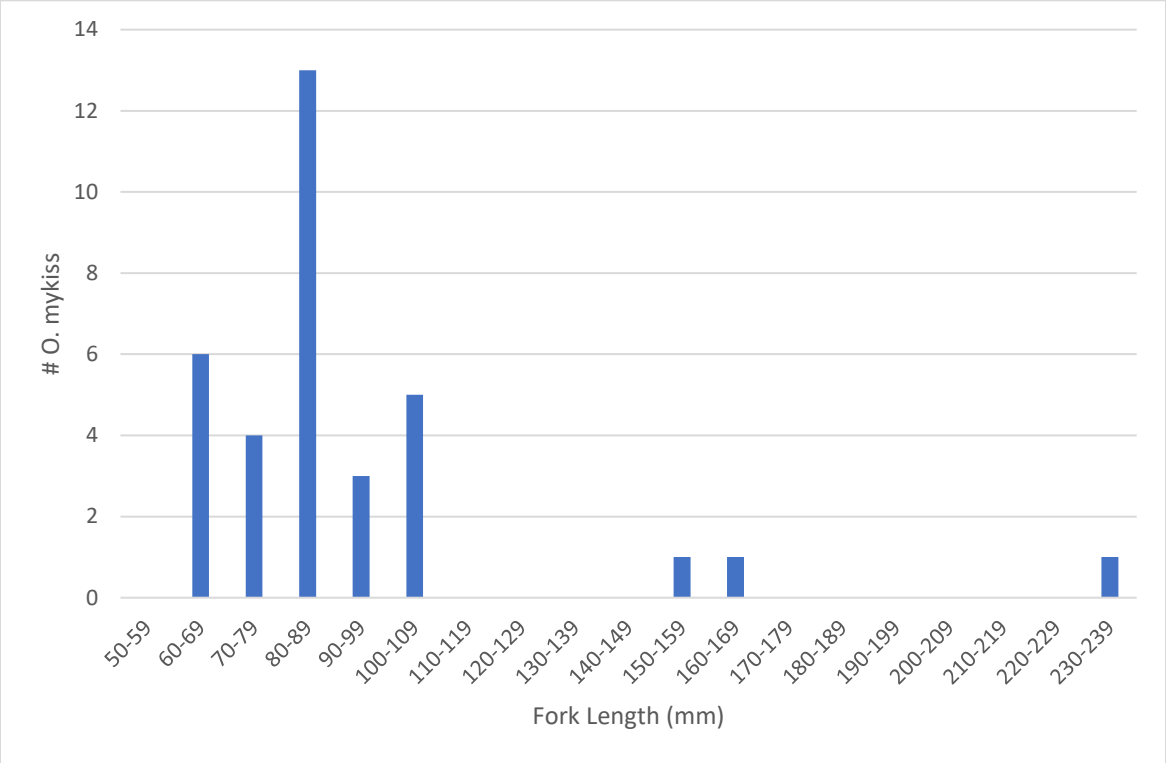


Figure 29: Guadalupe Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

The average *O. mykiss* density for all monitoring stations in 2019 was 0.14 fish per meter (based on the number of fish caught [n]). The number of *O. mykiss* observed in 2019 was lower than the average densities observed 2004-2018. The MLIP indicates that it is likely that the number of *O. mykiss* present in Guadalupe Creek is higher than what was observed during our sampling effort (0.25 fish per meter based on N). Based on the density of *O. mykiss* at each station, juvenile rearing appears to occur throughout Guadalupe Creek with higher densities observed in the middle of the system. This trend was observed in both 2018 and 2019 (Figure 28).

Guadalupe Creek supports four species of native fish, with multiple age classes of *O. mykiss.* No non-native species were captured during this sampling effort. Of the 34 *O.*

mykiss encountered during the sampling efforts, 19 had a Neascus-type parasitic infection commonly called “blackspot” disease. The visible black spots associated with fish are the metacercaria stage of the free-swimming parasite that produce a melanin-induced fibrous cyst (Schaaf et al. 2017). None of the fish observed were classified as a severe infection (raised cysts present on greater than 25% of the body). All infected fish were recorded as low with only a few raised cysts. The impacts to *O. mykiss* associated with this infection are not known.

When data from 2004-2018 is also considered, the results further indicate that *O. mykiss* production is variable, and the species is resilient. After not collecting any *O. mykiss* in Guadalupe Creek in 2015 and only two in 2016, there has been consistent production of O. mykiss in the system over the last few years. Guadalupe Creek is clearly important for production of *O. mykiss* in the Guadalupe River Watershed and supports an abundance of native fish as well.

3.3 Los Gatos Creek

Sampling occurred on Los Gatos Creek on October 11 and 15, 2019. All sampling days were sunny and clear. Flows on Los Gatos Creek, based on ALERT gage 5050 – Los Gatos Creek at Lincoln Avenue, were approximately 6.0 cfs.

LG001

This was the most downstream station sampled on Los Gatos Creek. As mentioned earlier, this station was moved downstream from the site previously sampled in 2018. The station is bordered by urban development including a city park, and there were numerous homeless encampments and other signs of human disturbance during sampling. The monitoring station was 40.0 m in length with an average wetted width of 7.5 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, glide and pool (Figure 30). The glide habitat was 53% of the habitat, while riffle consisted of 28%, followed by pool at the remaining 19%. The primary substrate was cobble with a secondary substrate of sand. Results of the water quality monitoring

and the ocular assessment of habitat complexity can be seen in Table 28. A concrete wall lined a portion of the east bank, contributing to artificial structure in the channel.

Three species of fish were captured during the survey: California roach, Sacramento sucker, and prickly sculpin. The most abundant species encountered was California roach (n=26), and the MLIP indicates the number present is likely higher than what was encountered. No *O. mykiss* were captured. Fish captured and associated population estimates are summarized in Table 29.



Figure 30: Photos of station LG001, looking upstream (left) and looking downstream (right).

Table 28: Station LG001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
578.00	16.50	8.07	0.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
0	2	1	2	2	1	2

Table 29: Number captured and population estimates at station LG001 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	26	39	0.00	39-39
Prickly sculpin	Yes	2	2	1.04	2-15
Sacramento sucker	Yes	1	1	0.73	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station LG001 had predicted capture rates for California roach higher than what was observed. All fish captured at this station were native, but non-native sunfish (*Micropterus spp*.) were observed downstream of the monitoring station. The habitat present could potentially support rearing of *O. mykiss*.

LG002

The station is situated amongst urban residential areas. Large stands of non-native *Arundo donax* were present along the entire right bank and a sakrete wall lined portions of the left bank. The monitoring station was 40.0 m in length with an average wetted width of 5.0 m and an average depth of 0.7 m. Four habitat types were present within the station: riffle, run, glide, and pool (Figure 31). The riffle habitat made up 15%, the run made up 20%, glide made up 43%, and the pool made up the remaining 22%. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 30.



Figure 31: Photos of station LG002, looking upstream (left) and looking downstream (right).

Table 30: Station LG002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
360.00	15.08	7.66	20.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	2	1	2	2	2	2

Five species of fish were captured: California roach, Sacramento sucker, green sunfish, spotted bass, and mosquitofish. The most abundant species encountered was California roach (n=43) and the MLIP indicates the number was likely higher than observed. No *O. mykiss* were captured. Fish captured and associated population estimates are summarized in Table 31.

Table 31: Number captured and population estimates at station LG002 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	43	47	3.89	43-55
Green sunfish	No	1	1	0.00	1-1
Mosquitofish	No	7	7	0.12	7-7
Sacramento sucker	Yes	4	4	0.21	4-5
Spotted bass	No	1	1	0.73	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Most of the fish captured were native, but three species of non-natives were encountered in limited numbers. Spotted bass are a known predator of *O. mykiss* with green sunfish having the potential to prey upon fry and eggs.

LG003

The station is bordered by residential development. Trash and other impacts associated with homeless encampments and other human uses were prevalent in the area surrounding this station. The monitoring station was 40.0 m in length with an average wetted width of 3.5 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and glide (Figure 32). The riffle habitat made up 28%, the run 65%, and the glide the remaining 7%. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 32.



Figure 32: Photos of station LG003, looking upstream (left) and looking downstream (right).

Table 32: Station LG003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
329.00	16.08	9.15	10.40			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	3	1	2	2	2	0

Three species of fish were captured during the survey: Sacramento sucker, channel catfish (*Ictalurus punctatus*), and spotted bass. Fish captured and associated population estimates are summarized in Table 33. Capture at this site was low. Only ten individual fish were captured. The most abundant species encountered was Sacramento sucker (n=7), but the remaining three individuals captured were non-native. No *O. mykiss* were captured.

Table 33: Number captured and population estimates at station LG003 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
Channel catfish	No	1	1	2.03	1-1
Sacramento sucker	Yes	7	7	1.20	7-10
Spotted bass	No	2	2	1.03	2-15

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

LG004

This is the most upstream station and it is situated amongst commercial development. This site was the location of the Valley Water Stream Maintenance Los Gatos Creek Instream Habitat Complexity Project. This project consisted of the implementation of large woody debris and the augmentation of gravel. Work was completed in the month prior to the sampling. It is likely the system has not fully acclimated to the changes associated with the restoration. The monitoring station was 40.0 m in length with an average wetted width of 4.5 m and an average depth of 0.35 m. Three habitat types were present within the station: riffle, run, and glide (Figure 33). The riffle habitat made up 28%, the run 15%, and the glide the remaining 57%. The primary substrate was cobble with a secondary substrate of gravel. Most of the cobble in the reach and the large woody debris present was part of the restoration project. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 34.

Three species of fish were captured during the survey: California roach, spotted bass, and pond loach (*Misgurnus anguillicaudatus;* Figure 34). Fish captured and associated population estimates are summarized in Table 35. This was the first occurrence of pond loach in Los Gatos Creek, and the first instance of the species recorded by Valley Water in Santa Clara County. Pond loach are a popular aquarium fish native to East Asia. Six individuals ranging from 50-86 mm in length were captured. The population estimate indicates the number of pond loach was likely higher than what was observed. Though two non-native species were observed, native California roach was the most abundant species encountered (n=13). No *O. mykiss* were captured at this monitoring station.

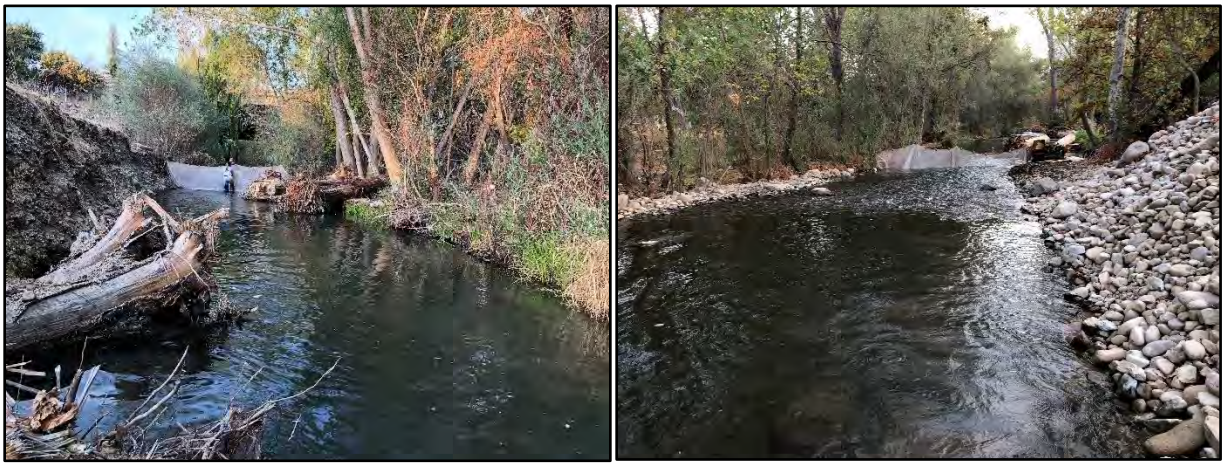


Figure 33: Photos of station LG004, looking upstream (left) and looking downstream (right).

Table 34: Station LG004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
337.00	16.54	7.21	23.50			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
1	3	2	0	2	2	2

Table 35: Number captured and population estimates at station LG004 on Los Gatos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	13	18	8.60	13-36
Pond loach	No	6	18	57.64	6-140
Spotted bass	No	1	1	2.03	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval



Figure 34: Pond loach (Misgurnus anguillicaudatus) captured at station LG004. This was the first occurrence of this species in Santa Clara detected by Valley Water staff.

Los Gatos Creek Discussion

No *O. mykiss* were collected in Los Gatos Creek in 2018 or 2019, although all stations had some suitable habitat complexity (i.e., undercut banks, large woody debris, or submerged roots) that could be used as refugia and had riffle habitat that should support fast-water feeding requirements. *O. mykiss* are present in the system, at least periodically, as they have been observed by others. For example, Hobbs et al. (2014) sampled Los Gatos Creek in January and February 2014 and captured a total of nine *O. mykiss* at two stations but captured none in October 2014 at a monitoring station near Bascom Avenue (Hobbs et al. 2015). There have been no other anecdotal reports of *O. mykiss* since 2014. It is likely that *O. mykiss* production is not high in this system, and/or Los Gatos Creek could still be recovering from drought conditions.

Los Gatos Creek had a relatively high abundance of native fish at all monitoring stations, though non-native species were captured at three of the four stations. A better understanding of occurrence and trends of fish populations are expected to develop as additional juvenile rearing data is collected. Currently, Los Gatos Creek has a higher

richness of non-natives compared with other systems in the Guadalupe Watershed, but habitat is present to support native fishes.

3.4 Alamitos Creek

Sampling occurred at four stations on Alamitos Creek on October 23 and 31, 2019. The weather was sunny and clear with no precipitation. Flows at the two upstream-most stations, based on ALERT gage 1544 Alamitos Creek below Almaden Reservoir, were approximately 4.5-5.1 cfs. Flows at the two downstream-most stations (AC001 and AC002), which are downstream of the confluence with Calero Creek, were 13.4-14.4 cfs, based on ALERT gage 5070 Alamitos Creek at Greystone.

AC001

This was the most downstream station sampled on Alamitos Creek. The station is situated in an urban residential area with a walking trail along the left bank. The monitoring station was 40 m in length with an average wetted width of 5.0 m and an average depth of 0.2 m. Two habitat types were present within the station: riffle and run (Figure 35). The riffle habitat made up 20% of the habitat and the run the remaining 80%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 36.



Figure 35: Photos of station AC001, looking upstream (left) and looking downstream (right).

Table 36: Station AC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
473	13.51	9.08	24.9			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
3	1	0	2	1	3	0

Five species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, Sacramento sucker, and tule perch (*Hysterocarpus traskii*). The most abundant species encountered was prickly sculpin (n=48). Four *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 37. The MLIP provided population estimates higher than what was recorded for Sacramento sucker. All fish species captured were native, except for tule perch. Tule perch are native to California and were historically observed in the Coyote Creek Watershed in 1922 (Hubbs 1925). This species was thought to be extirpated in Santa Clara County until 1999 when a single specimen was captured in Coyote Creek (VALLEY WATER 2015). Tule perch do not show up in the historic records in the Guadalupe Watershed, but are now established in Calero Reservoir (Leal et al. 2017). It is assumed that the reservoir is the source for the population in Alamitos Creek. Though the species is regionally native, it was likely not present in the Guadalupe Watershed until introductions to Calero Reservoir.

Table 37: Number captured and population estimates at station AC001 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	16	16	1.087	16-18
Prickly sculpin	Yes	48	48	0.972	48-50
O. mykiss	Yes	4	4	0.544	4-6
Sacramento sucker	Yes	14	15	2.274	14-20
Tule perch[1]	No	1	1	2.027	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

The number of *O. mykiss* collected in 2019 (n=4) was less than what was collected in 2018. The average density of *O. mykiss* observed in Alamitos Creek in 2018 was 0.20 *O. mykiss*/m. A more detailed analysis of results of the *O. mykiss* capture data is provided in the Alamitos Creek Discussion later in the document.

AC002

The station is situated in an urban residential area with a walking trail along the right bank. The monitoring station was 40.0 m in length with an average wetted width of 5.0 m and an average depth of 0.8 m. Three habitat types were present within the station: riffle, run, and pool (Figure 36). The riffle habitat made up 35% of the habitat, the run 35%, and a pool the remaining 30%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 38.

[1] Tule perch are native to California and were observed in the Coyote Creek watershed in 1922 (Hubbs 1925). Though the species is regionally native, it was likely not historically present in the Guadalupe Watershed. For this analysis the species is considered non-native.



Figure 36: Photos of station AC002, looking upstream (left) and looking downstream (right).

Table 38: Station AC002 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
473.00	17.40	7.61	18.80

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	1	1	0	2	2	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, and Sacramento sucker. The most abundant species encountered was prickly sculpin (n=36). One *O. mykiss* was captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 39.

Table 39: Number captured and population estimates at station AC002 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	13	13	0.33	13-14
Prickly sculpin	Yes	36	36	0.71	36-37
O. mykiss	Yes	1	1	0.00	1-1
Sacramento sucker	Yes	5	5	0.00	5-5

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

At station AC002 the MLIP did not provide population estimates higher than what was observed for any species. All fish encountered were native. The number of *O. mykiss* collected in 2019 (n=1) was less than what was collected in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Alamitos Creek Discussion section later in the document.

AC003

The station is located upstream of the Calero Creek confluence and is situated in an urban residential area. The right bank through half of the station has large boulders that were placed by a previous bank protection project. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.3 m. The channel had a single braid with a vegetated island dividing the channel. Four habitat types were present within the station: riffle, step-run, run, and pool (Figure 37). The riffle habitat only made up 12% of the habitat, the step run through the large boulders of the bank protection contributed to 50%, the run 8%, and the pool the remaining 30%. The primary substrate was boulder with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 40.



Figure 37: Photos of station AC003, looking upstream (left) and looking downstream (right).

Table 40: Station AC003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
429.00	10.76	7.72	18.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	4	1	1	2	2	0

Three species of fish were captured during the survey: *O. mykiss*, California roach, and Sacramento sucker. The most abundant species encountered was California roach (n=122). All fish encountered were native. Twenty-three *O. mykiss* were captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 41.

Table 41: Number captured and population estimates at station AC003 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	122	178	29.88	122-237
O. mykiss	Yes	23	25	3.00	23-31
Sacramento sucker	Yes	57	61	3.56	57-68

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC003 the MLIP provided population estimates higher than what was recorded for all species. The predicted number of *O. mykiss* is N=25 individuals. Both the observed and predicted number of *O. mykiss* is higher than what was observed in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Alamitos Creek Discussion section later in the document.

AC004

AC004 is the most upstream station on Alamitos Creek. Portions of the station were underneath the bridge that connects Almaden and Bertram Roads. The bridge footing extended into the channel. The monitoring station was 45.0 m in length with an average wetted width of 5.0 m and an average depth of 0.3 m. Four habitat types were present within the station: riffle, run, pool, and cascade (Figure 38). The riffle habitat made up 36% of the habitat, the run 44%, pool 13% and the cascade glide contributed the remaining 7%. The primary substrate was cobbles with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 42.



Figure 38: Photos of station AC004, looking upstream (left) and looking downstream (right).

Table 42: Station AC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)	Turbidity (NTU)			
418.00	16.51	7.63	15.8			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	2	1	1	4	2	1

Three species of fish were captured during the survey: *O. mykiss,* California roach, and prickly sculpin. All fish species captured were native. *O. mykiss* were the most abundant species present and of the 20 captured, 13 were ≥65 mm and were PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 43.

Table 43: Number captured and population estimates at station AC004 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	5	8	0.00	8-8
Prickly sculpin	Yes	1	1	0.00	1-1
O. mykiss	Yes	20	30	0.00	30-30

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC004 the MLIP provided population estimates higher than what was recorded for California roach and *O. mykiss*. Both estimates had a low standard error and high level of confidence. Both the observed and predicted number of *O. mykiss* is higher than what was observed in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Alamitos Creek Discussion section later in the document.

ACBONUS

This station is a randomly selected station that will move every year. In 2019, this station was located upstream of the Calero Creek confluence downstream of AC003. It is situated in an urban residential area. The monitoring station was 45.0 m in length with an average wetted width of 4.5 m and an average depth of 0.2 m. Two habitat types were present within the station: riffle and glide (Figure 39). The riffle habitat made up 41% of the habitat and the glide the remaining 59%. The primary substrate was silt with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 44.



Figure 39: Photos of station ACBONUS, looking upstream (left) and looking downstream (right).

Table 44: Station AC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**		**Turbidity (NTU)**		
421	15.56	7.76		5.9		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	2	0	1	2	1	0

Three species of fish were captured during the survey: *O. mykiss,* California roach, and Sacramento sucker. All fish species captured were native. Five *O. mykiss* were captured and PIT tagged prior to being released. Fish captured and associated population estimates are summarized in Table 45.

Table 45: Number captured and population estimates at station AC004 on Alamitos Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	164	244	37.24	164-317
O. mykiss	Yes	5	5	0.17	5-5
Sacramento sucker	Yes	24	41	23.69	24-89

In station ACBONUS the MLIP provided population estimates higher than what was captured for California roach and Sacramento sucker. The predicted number of *O. mykiss* remained the same as the observed. A more detailed analysis of *O. mykiss* capture data is provided in the Alamitos Creek Discussion section below.

Alamitos Creek Discussion

A total of 53 *O. mykiss* were collected in the five Alamitos Creek monitoring stations. The MLIP estimated the population of *O. mykiss* within the monitoring stations to be 65 fish. The average standardized density of *O. mykiss* in Alamitos Creek in 2019 was 0.25 *O. mykiss*/m with an estimated density 0.31 *O. mykiss*/m. When compared to the average standardized density in 2018 in Alamitos Creek (0.20 *O. mykiss*/m) the overall densities of fish were higher in 2019. Individual stations saw fluctuations in numbers observed, but overall more fish were present (Figure 40). The average density in Alamitos Creek in both 2018 and 2019 was higher than the average density of repeated monitoring stations between 2004-2018 on Guadalupe Creek (0.17 *O. mykiss*/m).

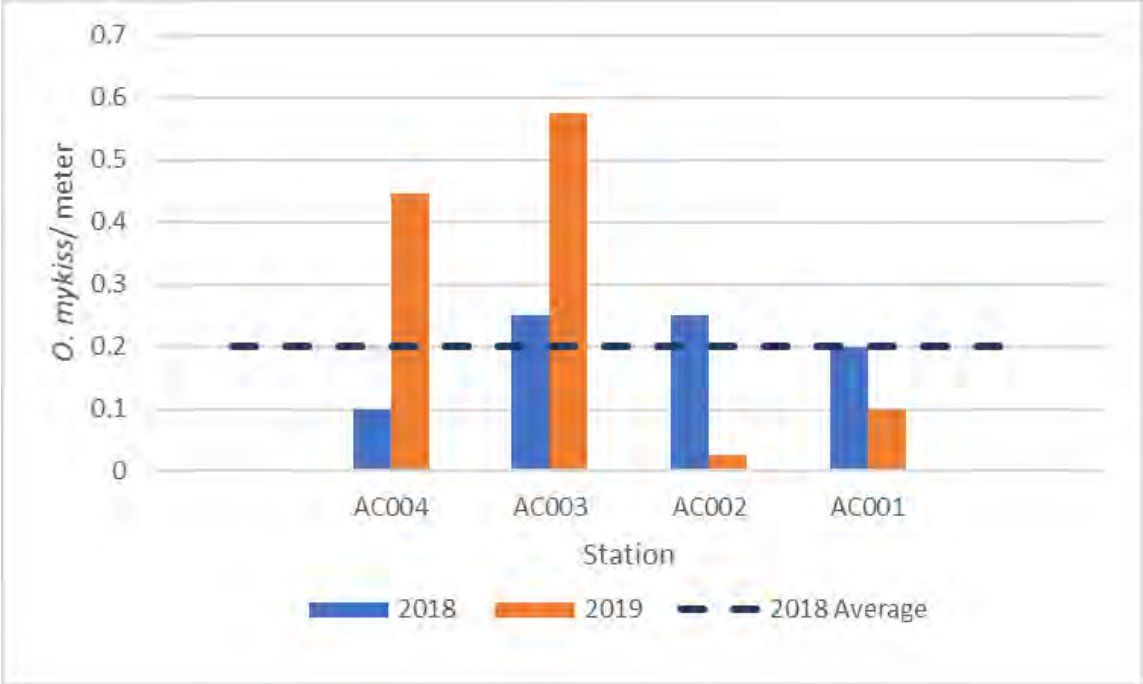


Figure 40: Capture densities of *O. mykiss* 2018 and 2019 within all Alamitos Creek monitoring stations.

Fork-lengths ranged from 43 mm to 280 mm (Figure 41). Based on Moyle (2002) and Smith and Leicester (2016) growth rates, most fish captured were young of the year, with fish extending potentially into their third year. Based on the results of the WY 2019 sampling, Alamitos Creek had successful reproduction and multiple age classes. The presence of *O. mykiss* in the 40 to 60 mm size range indicates late reproduction or growth rates are slower than what was observed by Smith Leicester (2016) and Moyle (2002). *O. mykiss* in this system continue to show signs of blackspot disease. Of the 53 captured, 28 had visible symptoms, with approximately 50% recorded as low (a few raised cysts) and the remaining fish as moderate (10-25% of the body experiencing symptoms) severity of infection. No infection was classified as severe (greater than 25% of the body experiencing symptoms. Of all systems sampled, blackspot disease was most prevalent in Alamitos Creek *O. mykiss*.

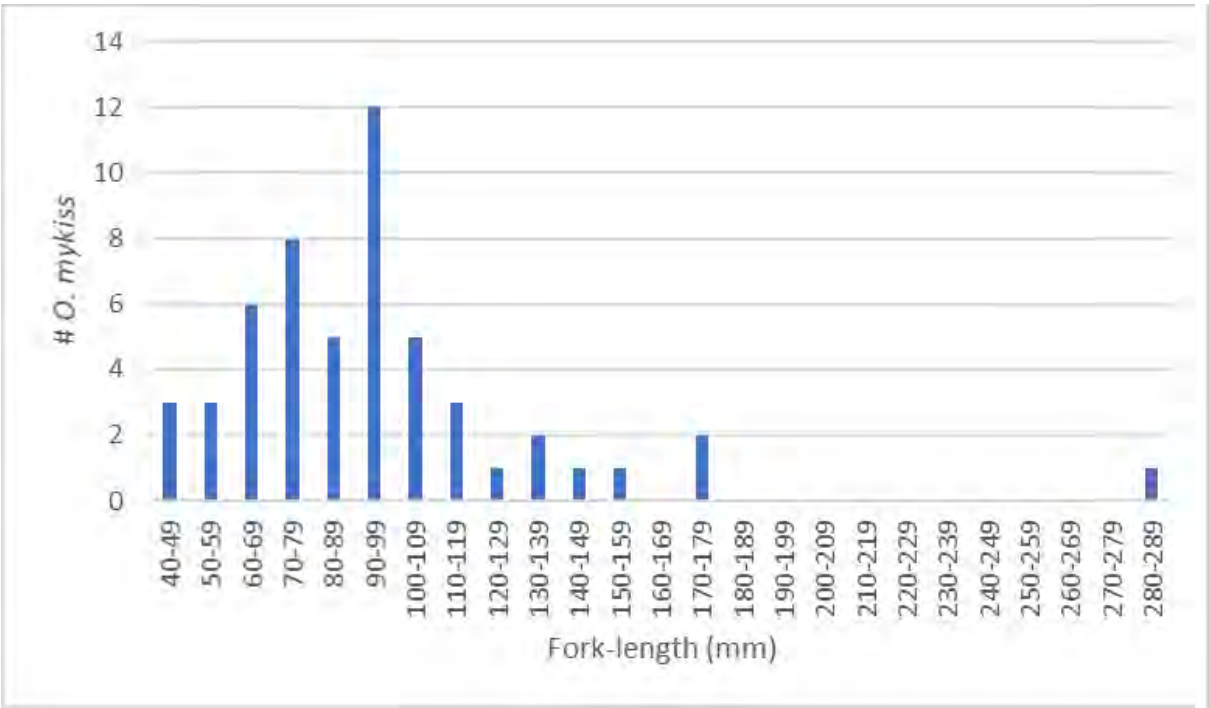


Figure 41: Alamitos Creek *O. my*kiss length histogram. All measurements are in fork-length and binned in 10 mm increments.

Alamitos Creek is also supporting four other species of native fish and continues to show evidence of a small population of tule perch. This species was the only fish captured that is considered to be non-native, though it is native to Santa Clara County. Tule perch are not be considered a predator of *O. mykiss*.

3.5 Calero Creek

Sampling occurred at three stations on Calero Creek on October 28, 2019. The weather was sunny and clear. Flows on Calero Creek based on ALERT gage 5013 Calero Creek below Calero Reservoir were approximately 10.0 cfs during the sampling period.

CC001

This was the most downstream station sampled on Calero Creek. The station is situated in urban residential and is approximately 300.0 m upstream of the confluence with Alamitos Creek. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.4 m. Three habitat types were present within

the station: riffle, run, and pool (Figure 42). The riffle habitat made up 63% of the habitat, the run 30%, and the pool the remaining 7%. A small side channel pool was present. The primary substrate was gravel with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 46.



Figure 42: Photos of station CC001, looking upstream (left) and looking downstream (right).

Table 46: Station CC001 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
473.00	15.14	9.92	32.10

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
4	1	1	2	2	2	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, and Sacramento sucker. The station had a low capture rate, with only nine fish captured. Three individuals were captured of both *O. mykiss* and Sacramento

sucker. All three of the *O. mykiss* were PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 47.

Table 47: Number captured and population estimates at station CC001 on Calero Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	1	1	0	1-1
Prickly sculpin	Yes	2	2	0.384	2-7
O. mykiss	Yes	3	3	0	3-3
Sacramento sucker	Yes	3	3	0.709	3-6

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC001 the MLIP does not provide population estimates higher than what was observed. The number of *O. mykiss* is lower than what was observed in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Calero Creek Discussion section later in the document.

CC002

The station is situated in an urban residential area. A small sakrete structure at an outfall was present. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.3 m. Two habitat types were present within the station: riffle and run (Figure 43). The riffle habitat made up 40% of the habitat and the run made up 60%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 48.



Figure 43: Photos of station CC002, looking upstream (left) and looking downstream (right).

Table 48: Station CC002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
459.00	14.30	7.57		34.00		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	1	1	2	3	3	1

Four species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, and Sacramento sucker. The most abundant species encountered was California roach (n=8) and Sacramento sucker (n=8). One *O. mykiss* was captured and PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 49.

Table 49: Number captured and population estimates at station CC002 on Calero Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	8	10	4.718	8-21
Prickly sculpin	Yes	3	3	1.271	3-8
O. mykiss	Yes	1	1	0.00	1-1
Sacramento sucker	Yes	8	10	4.718	8-21

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC002 the MLIP provided population estimates higher than what was recorded for California roach and Sacramento sucker. All fish species captured were native. The number of *O. mykiss* is lower than what was observed in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Calero Creek Discussion section later in the document.

CC003

The station is situated in a rural/agricultural area. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.25 m. Three habitat types were present within the station: riffle, run, and pool (Figure 44). The riffle and run habitat each made up 35% of the habitat with the pool making up the remaining 30%. The primary substrate was gravel with a secondary substrate of sand. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 50.



Figure 44: Photos of station CC001, looking upstream (left) and looking downstream (right).

Table 50: Station CC003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	Temperature (°C)	Dissolved Oxygen (mg/l)		Turbidity (NTU)		
421	14.63	7.10		61.7		
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	Boulders	Woody Debris	Undercut Banks	Overhanging Vegetation	Roots	Artificial Structures
2	0	1	2	3	2	0

Three species of fish were captured during the survey: *O. mykiss,* California roach, and Sacramento sucker. The most abundant species encountered was California roach (n=20). Three of the four *O. mykiss* captured were PIT tagged at this station. Fish captured and associated population estimates are summarized in Table 51.

Table 51: Number captured and population estimates at station CC003 on Calero Creek.

Species	Native	n	N	SE	95% CI
California roach	Yes	20	22	2.96	20-28
O. mykiss	Yes	4	4	0.54	4-6
Sacramento sucker	Yes	16	17	2.24	16-22

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC003 the MLIP provided population estimates higher than what was recorded California roach and Sacramento sucker. The number of *O. mykiss* is lower than what was observed in 2018. A more detailed analysis of *O. mykiss* capture data is provided in the Calero Creek Discussion section below.

Calero Creek Discussion

A total of 8 *O. mykiss* were collected in three monitoring stations. The MLIP did not provide an estimation higher than what was encountered. The average standardized density of *O. mykiss* in Calero Creek in 2019 was 0.07 *O. mykiss*/m. When compared to the average standardized density in 2018 in Calero Creek (0.14 *O. mykiss*/m) the overall density of *O. mykiss* was half of what was observed in 2018. All stations saw a decline in number of individuals observed (Figure 45). The average density in Calero Creek in both 2018 and 2019 was lower than the observed density of repeated monitoring stations between 2004-2018 on Guadalupe Creek (0.17 *O. mykiss*/m) and on Alamitos Creek (0.20 *O. mykiss*/m). Guadalupe and Alamitos creeks are larger sub-watersheds, so it is expected that they would support higher fish densities. Although Calero Creek had a lower rearing density than Guadalupe Creek and Alamitos Creek, it still had *O. mykiss* reproduction and is contributing to the overall production in the Guadalupe Watershed. Blackspot disease was observed on two *O. mykiss* in Calero Creek, but severity on both fish was low.

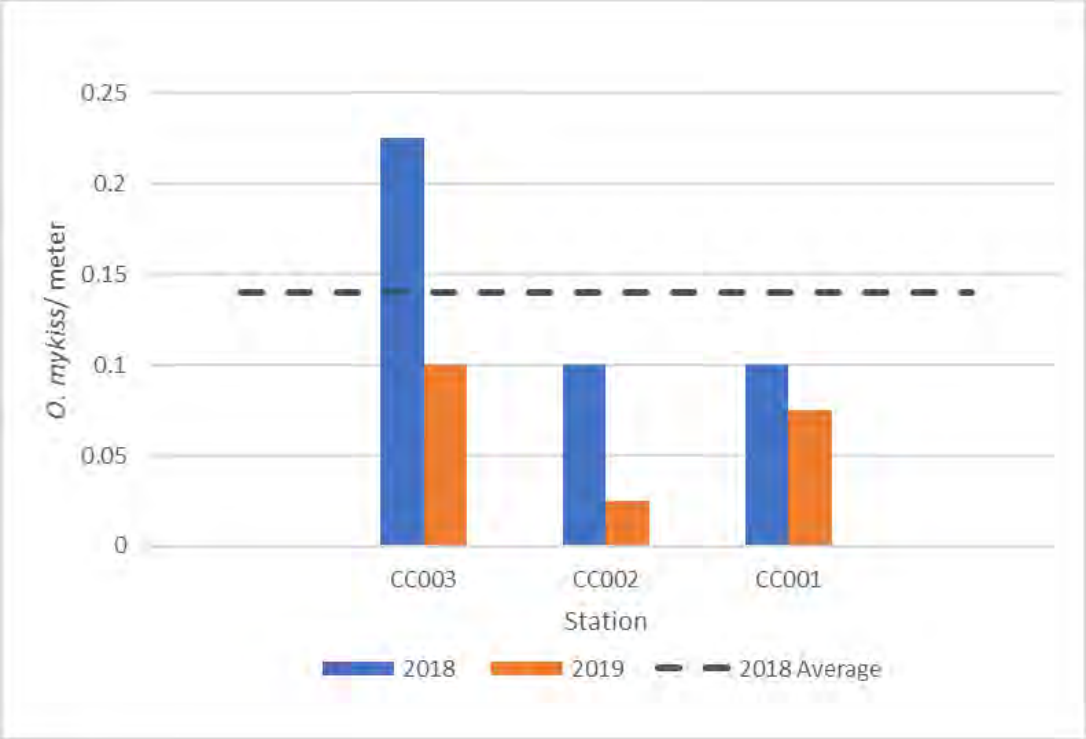


Figure 45: Capture densities of O. mykiss in 2018 and 2019 within all Calero Creek monitoring stations.

Fork-lengths ranged from 56 mm to 280 mm (Figure 46). Based on Moyle (2002) growth rates, *O. mykiss* captured in Calero Creek in 2019 were mostly young-of-the-year, with some fish in their second year, and a single fish potentially extending into its third year. Based on Smith and Leicester (2016) growth rates from Guadalupe Creek, all but one *O. mykiss* captured in 2019 were young-of-the-year with the one fish likely in its third year. Calero Creek is supporting at least two age classes of *O. mykiss*, with a potential of three (Figure 46). Based on the results of the WY 2019 sampling, Calero Creek supports rearing of *O. mykiss,* and had successful reproduction and summer rearing in 2018. Again, like in Alamitos Creek, the presence of *O. mykiss* less than 60 mm could indicate late reproduction in spring 2019, or slower growth rates.

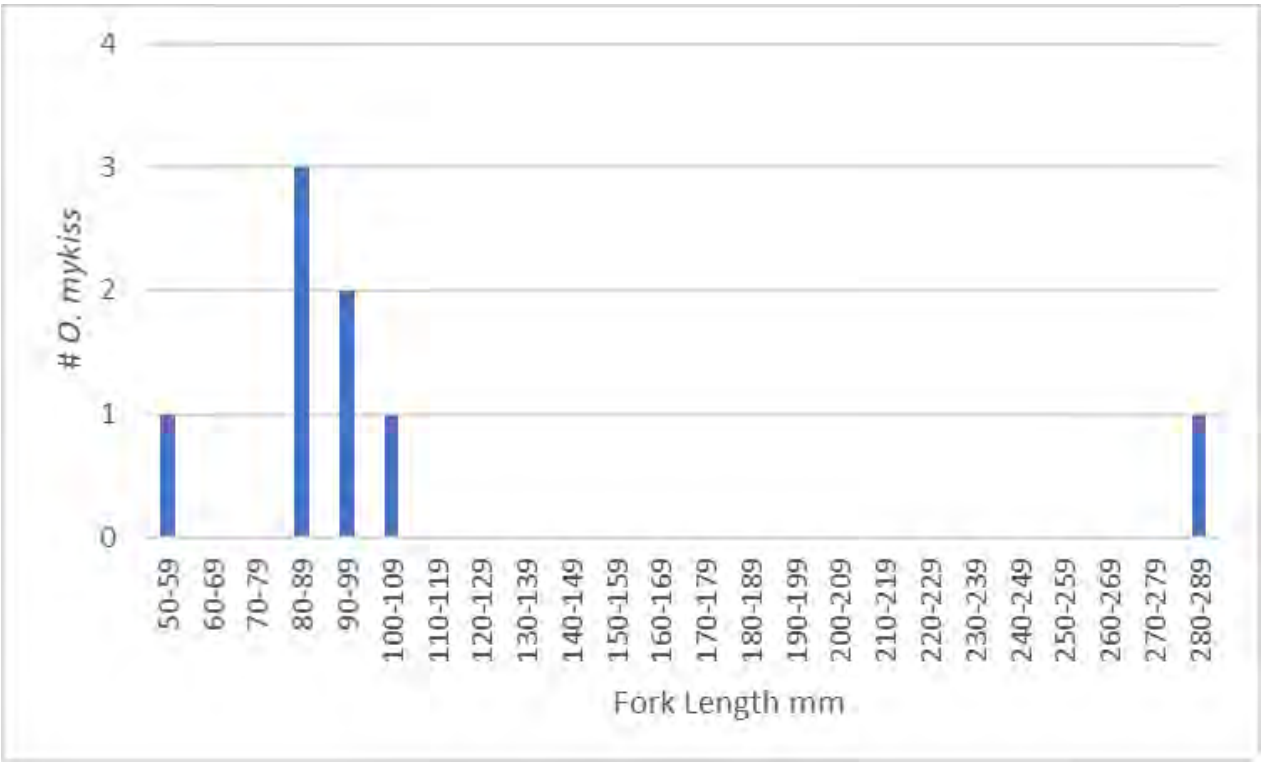


Figure 46: Calero Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

A total of four native species were detected during this sampling effort. No non-native species were encountered.

4. Conclusion

In WY2019, juvenile *O. mykiss* were observed in the Guadalupe River, Guadalupe Creek, Alamitos Creek, and Calero Creek. They were not observed in Los Gatos Creek. This was the first detection of *O. mykiss* in the Guadalupe River since 2014. It is unknown if it is normal for no detections to occur in Los Gatos Creek in some years, as this is only the second year of sampling this creek, and previous sampling was done at sporadic intervals. It is important to remember that electrofishing sampling only allows for specific habitats to be sampled. It is not feasible in deep pools, which may be the preferred habitat for *O. mykiss* inhabiting this system.

The average densities (*O. mykiss*/m) and median length of *O. mykiss* detected in Guadalupe River and Guadalupe, Alamitos, and Calero Creeks can be seen in Table

52. Alamitos Creek had the highest densities, with Calero Creek supporting the largest average size with the exception of Guadalupe River where only a single *O. mykiss* was encountered. Figure 47 shows the size distribution of all collected *O. mykiss* in the Guadalupe Watershed. Alamitos and Calero Creek are producing slightly larger fish, but the overall size distribution is relatively similar between sub-watersheds. Based on the size range of fish collected, production and successful summer rearing occurred and multiple age classes were present in the Guadalupe Watershed in 2019. The Guadalupe River did not have any *O. mykiss* that would be considered young of the year. It is likely no reproduction is occurring in this portion of the watershed and fish are only using it for rearing and staging prior to outmigration. Calero Creek supports larger fish than other upstream tributaries.

Table 52: 2019 average density and length of *O. mykiss* captured within Guadalupe, Alamitos, and Calero Creeks.

Sub-Watershed	*O. mykiss*/m	Median length
Guadalupe River	<0.01	248.0
Guadalupe Creek	0.14	84.5
Calero Creek	0.07	90.5
Alamitos Creek	0.31	90.0

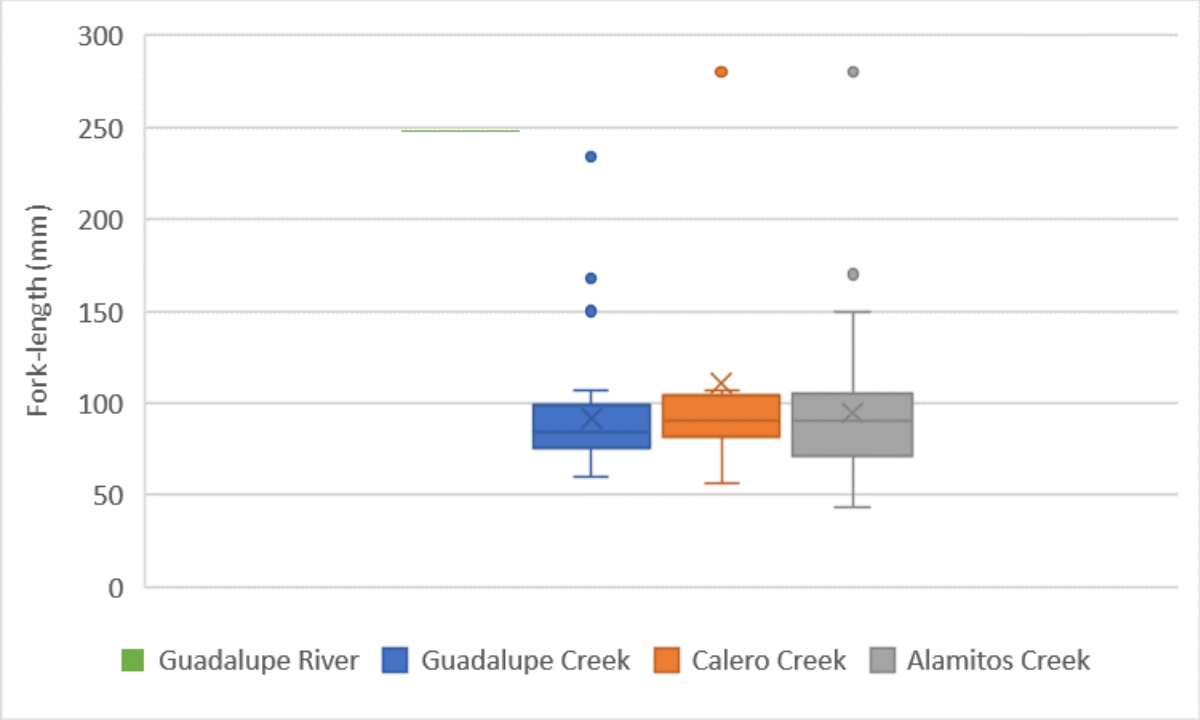


Figure 47*:* Box plot of *O. mykiss* size distribution (fork-length) for Guadalupe River, Guadalupe, Calero, and Alamitos Creek sub-watersheds. The box displays the first and third quartiles, the median (line within the box), mean (x symbol), with whiskers indicating the highest and lowest points within 1.5 times the interquartile range, and outlier points that fall outside the 1.5 times the interquartile range.

In addition to *O. mykiss* data, information on the presence of non-native fish species in the Guadalupe Watershed was obtained. No non-native species were collected in Guadalupe or Calero Creek. Alamitos Creek had a single tule perch, which are considered non-native as they historically did not occur in the watershed, but are not a predator to *O. mykiss*. Los Gatos Creek and Guadalupe River each had four non-native species, including largemouth bass and spotted bass which are considered to be major predators of juvenile *O. mykiss,* though all other non-native species can impact the habitat and natural communities within the system. Los Gatos Creek had the highest percentage of non-native species detected, with over 16% of captured fish being non-native. This included a new non-native species (Pond loach) not previously detected in the County. Guadalupe River had approximately 5% non-native fish species, which is a reduction from 2018. Looking at the Guadalupe Watershed as a whole, the overall percentage of non-native fish is less than 2% of all fish observed (Table 53).

Table 53: Total capture of fish per sub-watershed and percentage of total capture that was non-native species.

Sub-watershed	Guadalupe River	Guadalupe Creek	Los Gatos Creek	Alamitos Creek	Calero Creek	Guadalupe Watershed
Total Fish Captured	504	796	115	631	69	2,115
Non-native Fish Captured	24	0	18	1	0	43
Percent Non-native	4.8%	0.00%	15.7%	<0.01%	0.00%	2.0%

Juvenile *O. mykiss* are persisting in the Guadalupe Watershed, with multiple age classes present. Non-native fish are contributing to a small percentage of the total abundance, with no detections in the upper watershed. Since this is the second year of expanded monitoring it is difficult to assess any trends at this time, but as more data becomes available a better understanding of the Guadalupe Watershed will develop.

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Appendix A

Date	Creek	Species	Weight (g)	Length (mm)	PIT ID (Decimal)
12/16/2013	Guadalupe River	O. mykiss	-	134	982.000361656209
12/16/2013	Guadalupe River	O. mykiss	-	136	982.000361656215
12/16/2013	Guadalupe River	O. mykiss	-	155	982.000361656218
12/16/2013	Guadalupe River	O. mykiss	-	142	982.000361656222
12/16/2013	Guadalupe River	O. mykiss	-	-	982.000361656226
12/16/2013	Guadalupe River	O. mykiss	-	129	982.000361656230
12/16/2013	Guadalupe River	O. mykiss	-	133	982.000361656235
12/16/2013	Guadalupe River	O. mykiss	-	163	982.000361656237
12/16/2013	Guadalupe River	O. mykiss	-	125	982.000361656243
12/16/2013	Guadalupe River	O. mykiss	-	172	982.000361656249
12/16/2013	Guadalupe River	O. mykiss	-	151	982.000361656258
12/16/2013	Guadalupe River	O. mykiss	-	110	982.000362992258
12/16/2013	Guadalupe River	O. mykiss	-	160	982.000361656260
12/16/2013	Guadalupe River	O. mykiss	-	129	982.000361656263
12/16/2013	Guadalupe River	O. mykiss	-	230	982.000361656267
12/16/2013	Guadalupe River	O. mykiss	-	118	982.000362992269
12/16/2013	Guadalupe River	O. mykiss	-	175	982.000361656269
12/16/2013	Guadalupe River	O. mykiss	-	144	982.000361656274
12/16/2013	Guadalupe River	O. mykiss	-	122	982.000361656277
12/16/2013	Guadalupe River	O. mykiss	-	142	982.000361656278
12/16/2013	Guadalupe River	O. mykiss	-	112	982.000362992279
12/16/2013	Guadalupe River	O. mykiss	-	149	982.000361656280
12/16/2013	Guadalupe River	O. mykiss	-	135	982.000361656294
12/16/2013	Guadalupe River	O. mykiss	-	106	982.000362992296
12/16/2013	Guadalupe River	O. mykiss	-	122	982.000362992356
1/17/2014	Guadalupe River	O. mykiss	-	135	982.000361656216
1/17/2014	Los Gatos Creek	O. mykiss	-	115	982.000361656217
1/17/2014	Los Gatos Creek	O. mykiss	-	164	982.000361656229
1/17/2014	Guadalupe River	O. mykiss	-	156	982.000361656238
1/17/2014	Guadalupe River	O. mykiss	-	133	982.000361656247
1/17/2014	Guadalupe River	O. mykiss	-	120	982.000361656250
1/17/2014	Guadalupe River	O. mykiss	-	115	982.000361656252
1/17/2014	Guadalupe Creek	O. mykiss	-	80	982.000362992263
1/17/2014	Guadalupe River	O. mykiss	-	190	982.000361656264
1/17/2014	Guadalupe River	O. mykiss	-	150	982.000361656265
1/17/2014	Guadalupe Creek	O. mykiss	-	104	982.000362992272
1/17/2014	Guadalupe Creek	O. mykiss	-	85	982.000362992278
1/17/2014	Los Gatos Creek	O. mykiss	-	142	982.000361656288
1/17/2014	Guadalupe Creek	O. mykiss	-	93	982.000362992289
1/17/2014	Guadalupe Creek	O. mykiss	-	79	982.000362992290
1/17/2014	Guadalupe River	O. mykiss	-	119	982.000361656290
1/17/2014	Los Gatos Creek	O. mykiss	-	126	982.000361656298
1/17/2014	Los Gatos Creek	O. mykiss	-	89	982.000362992298
1/17/2014	Los Gatos Creek	O. mykiss	-	138	982.000361656299
1/17/2014	Guadalupe Creek	O. mykiss	-	75	982.000362992302
1/17/2014	Guadalupe Creek	O. mykiss	-	110	982.000362992303

1/17/2014	Guadalupe Creek	O. mykiss	-	155	982.000361656305
1/17/2014	Guadalupe Creek	O. mykiss	-	91	982.000362992306
1/17/2014	Guadalupe Creek	O. mykiss	-	91	982.000362992312
1/17/2014	Guadalupe Creek	O. mykiss	-	92	982.000362992315
1/17/2014	Guadalupe Creek	O. mykiss	-	71	982.000362992325
1/17/2014	Guadalupe Creek	O. mykiss	-	102	982.000362992327
1/17/2014	Guadalupe Creek	O. mykiss	-	79	982.000362992328
1/17/2014	Guadalupe Creek	O. mykiss	-	80	982.000362992330
1/17/2014	Guadalupe Creek	O. mykiss	-	110	982.000362992333
1/17/2014	Guadalupe Creek	O. mykiss	-	69	982.000362992340
1/17/2014	Guadalupe River	O. mykiss	-	138	982.000361656521
2/12/2014	Guadalupe River	O. mykiss	-	148	982.000361656219
2/12/2014	Guadalupe River	O. mykiss	-	189	982.000361656225
2/12/2014	Guadalupe River	O. mykiss	-	149	982.000361656227
2/12/2014	Guadalupe River	O. mykiss	-	179	982.000361656231
2/12/2014	Guadalupe River	O. mykiss	-	147	982.000361656242
2/12/2014	Guadalupe River	O. mykiss	-	156	982.000361656244
2/12/2014	Guadalupe River	O. mykiss	-	132	982.000361656272
2/12/2014	Guadalupe River	O. mykiss	-	193	982.000361656291
2/21/2014	Los Gatos Creek	O. mykiss	-	116	982.000361656213
2/21/2014	Los Gatos Creek	O. mykiss	-	142	982.000361656270
2/21/2014	Guadalupe River	O. mykiss	-	145	982.000361656311
2/21/2014	Los Gatos Creek	O. mykiss	-	112	982.000361656454
3/14/2014	Guadalupe River	O. mykiss	-	153	982.000361654515
3/15/2014	Pond A8	striped bass		520	982.000362654458
3/15/2014	Pond A8	striped bass		500	982.000362654476
3/15/2014	Pond A8	striped bass		530	982.000362655000
3/15/2014	Pond A8	striped bass		500	982.000362654505
3/15/2014	Pond A8	striped bass		440	982.000362654514
3/15/2014	Pond A8	striped bass		470	982.000362654539
4/17/2014	Pond A5	Leopard Shark	-	1219	982.000362654450
4/17/2014	Pond A5	Leopard Shark	-	838	982.000362654453
4/17/2014	Pond A5	Leopard Shark	-	864	982.000362654461
4/17/2014	Pond A5	Leopard Shark	-	914	982.000362654494
4/17/2014	Pond A5	Leopard Shark	-	864	982.000362654521
4/17/2014	Pond A5	Leopard Shark	-	889	982.000362654528
4/17/2014	Pond A8	striped bass		737	982.000362654448
4/17/2014	Pond A8	striped bass		762	982.000362654460
4/17/2014	Pond A8	striped bass		660	982.000362654466
4/17/2014	Pond A8	striped bass		787	982.000362654467
4/17/2014	Pond A8	striped bass		330	982.000362655150
4/17/2014	Pond A8	striped bass		762	982.000362654524
4/17/2014	Pond A8	striped bass		965	982.000362654529
4/17/2014	Pond A8	striped bass		305	982.000362654534
4/17/2014	Pond A8	striped bass		305	982.000362654537
4/17/2014	Pond A8	striped bass		838	982.000362654540
4/17/2014	Pond A8	striped bass		508	982.000362654543

10/19/2014	Alamitos Creek	O. mykiss		105	982.000362992262
10/19/2014	Alamitos Creek	O. mykiss		98	982.0003629923
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992288
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992271
10/19/2014	Guadalupe Creek	O. mykiss		65	982.000362992351
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992281
10/19/2014	Guadalupe Creek	O. mykiss		90	982.000362992331
10/19/2014	Guadalupe Creek	O. mykiss		81	982.000362992285
11/2/2014	Guadalupe Creek	O. mykiss		146	982.000362655573
11/2/2014	Guadalupe Creek	O. mykiss		100	982.000362992305
11/2/2014	Guadalupe Creek	O. mykiss		117	982.000362992280
11/2/2014	Guadalupe Creek	O. mykiss		173	982.000362654463
11/2/2014	Guadalupe Creek	O. mykiss		124	982.000362654546
11/2/2014	Guadalupe Creek	O. mykiss		86	982.000362992307
11/2/2014	Guadalupe Creek	O. mykiss		67	982.000362992342
11/2/2014	Guadalupe Creek	O. mykiss		96	982.000362654480
11/3/2014	Guadalupe Creek	O. mykiss		NA	982.000360826977
11/3/2014	Guadalupe Creek	O. mykiss		93	982.000362992308
11/3/2014	Guadalupe Creek	O. mykiss		85	982.000360826958
11/3/2014	Guadalupe Creek	O. mykiss		72	982.000362992287
11/3/2014	Guadalupe Creek	O. mykiss		123	982.000362655643
11/3/2014	Guadalupe Creek	O. mykiss		120	982.000362655612
11/3/2014	Guadalupe Creek	O. mykiss		78	982.000362992353
11/3/2014	Guadalupe Creek	O. mykiss		139	982.000362655554
11/3/2014	Guadalupe Creek	O. mykiss		168	982.000362655626
11/3/2014	Guadalupe Creek	O. mykiss		72	982.000362992295
11/3/2014	Guadalupe Creek	O. mykiss		65	982.000362992317
11/3/2014	Guadalupe Creek	O. mykiss		88	982.000362992310
9/17/2018	Alamitos Creek	O. mykiss	43.06	146	900.226000319370
9/17/2018	Alamitos Creek	O. mykiss	15.14	111	900.226000319353
9/17/2018	Alamitos Creek	O. mykiss	-	199	900.226000319320
9/17/2018	Alamitos Creek	O. mykiss	17.20	109	900.226000319322
9/17/2018	Alamitos Creek	O. mykiss	13.30	102	900.226000319339
9/17/2018	Alamitos Creek	O. mykiss	15.09	107	900.226000319313
9/17/2018	Alamitos Creek	O. mykiss	8.33	89	900.226000319367
9/17/2018	Alamitos Creek	O. mykiss	-	248	900.226000319355
9/17/2018	Alamitos Creek	O. mykiss	12.92	103	900.226000319350
9/17/2018	Alamitos Creek	O. mykiss	21.42	119	900.226000319366
9/17/2018	Alamitos Creek	O. mykiss	19.34	117	900.226000319375
9/17/2018	Alamitos Creek	O. mykiss	16.51	111	900.226000319326
9/17/2018	Alamitos Creek	O. mykiss	23.78	122	900.226000319387
9/17/2018	Alamitos Creek	O. mykiss	26.74	132	900.226000319376
9/17/2018	Alamitos Creek	O. mykiss	30.42	141	900.226000319319
9/17/2018	Alamitos Creek	O. mykiss	32.10	136	900.226000319352
9/17/2018	Alamitos Creek	O. mykiss	13.30	103	900.226000319314
9/17/2018	Alamitos Creek	O. mykiss	32.70	138	900.226000319391
9/17/2018	Alamitos Creek	O. mykiss	25.26	129	900.226000319310

9/17/2018	Alamitos Creek	O. mykiss	11.50	97	900.226000319372
9/17/2018	Alamitos Creek	O. mykiss	81.27	186	900.226000319301
9/17/2018	Alamitos Creek	O. mykiss	19.01	117	900.226000319384
9/17/2018	Alamitos Creek	O. mykiss	14.39	104	900.226000319316
9/17/2018	Alamitos Creek	O. mykiss	11.97	102	900.226000319397
9/17/2018	Alamitos Creek	O. mykiss	10.00	95	900.226000319388
9/17/2018	Alamitos Creek	O. mykiss	14.48	106	900.226000319360
9/17/2018	Alamitos Creek	O. mykiss	18.58	115	900.226000319321
9/17/2018	Alamitos Creek	O. mykiss	23.03	122	900.226000319348
10/16/2018	Guadalupe Creek	O. mykiss	7.81	83	900.226000319227
10/16/2018	Guadalupe Creek	O. mykiss	9.25	87	900.226000319276
10/16/2018	Guadalupe Creek	O. mykiss	14.28	106	900.226000319293
10/16/2018	Guadalupe Creek	O. mykiss	4.75	67	900.226000319318
10/16/2018	Guadalupe Creek	O. mykiss	4.62	72	900.226000319305
10/16/2018	Guadalupe Creek	O. mykiss	3.72	66	900.226000319334
10/16/2018	Guadalupe Creek	O. mykiss	6.37	72	900.226000319341
10/16/2018	Guadalupe Creek	O. mykiss	3.58	65	900.226000319308
10/16/2018	Guadalupe Creek	O. mykiss	31.33	138	900.226000319389
10/16/2018	Guadalupe Creek	O. mykiss	6.82	81	900.226000319385
10/16/2018	Guadalupe Creek	O. mykiss	4.58	66	900.226000319338
10/16/2018	Guadalupe Creek	O. mykiss	5.32	74	900.226000319324
10/16/2018	Guadalupe Creek	O. mykiss	6.93	86	900.226000319364
10/16/2018	Guadalupe Creek	O. mykiss	6.66	79	900.226000319345
10/16/2018	Guadalupe Creek	O. mykiss	8.33	84	900.226000319358
10/16/2018	Guadalupe Creek	O. mykiss	6.12	76	900.226000319329
10/16/2018	Guadalupe Creek	O. mykiss	4.97	70	900.226000319351
10/17/2018	Guadalupe Creek	O. mykiss	5.62	75	900.226000319346
10/17/2018	Guadalupe Creek	O. mykiss	4.22	66	900.226000319394
10/17/2018	Guadalupe Creek	O. mykiss	6.02	79	900.226000319386
10/17/2018	Guadalupe Creek	O. mykiss	5.90	77	900.226000319340
10/17/2018	Guadalupe Creek	O. mykiss	4.52	70	900.226000319317
10/17/2018	Guadalupe Creek	O. mykiss	5.14	72	900.226000319337
10/17/2018	Guadalupe Creek	O. mykiss	8.05	86	900.226000319344
10/17/2018	Guadalupe Creek	O. mykiss	4.23	68	900.226000319330
10/17/2018	Guadalupe Creek	O. mykiss	6.06	75	900.226000319307
10/17/2018	Guadalupe Creek	O. mykiss	4.08	67	900.226000319309
10/17/2018	Guadalupe Creek	O. mykiss	3.83	65	900.226000319333
10/17/2018	Guadalupe Creek	O. mykiss	5.66	74	900.226000319361
10/17/2018	Guadalupe Creek	O. mykiss	96.04	199	900.228000613702
10/17/2018	Guadalupe Creek	O. mykiss	4.61	65	900.226000319381
10/17/2018	Guadalupe Creek	O. mykiss	6.62	76	900.226000319342
10/17/2018	Guadalupe Creek	O. mykiss	4.35	66	900.226000319399
10/17/2018	Guadalupe Creek	O. mykiss	4.63	70	900.226000319377
10/17/2018	Guadalupe Creek	O. mykiss	5.68	72	900.226000319371
10/17/2018	Guadalupe Creek	O. mykiss	6.23	75	900.226000319395
10/17/2018	Guadalupe Creek	O. mykiss	4.95	69	900.226000319325
10/17/2018	Guadalupe Creek	O. mykiss	6.20	78	900.226000319356

10/17/2018	Guadalupe Creek	O. mykiss	6.22	79	900.226000319374
10/17/2018	Guadalupe Creek	O. mykiss	4.36	69	900.226000319379
10/17/2018	Guadalupe Creek	O. mykiss	4.53	67	900.226000319354
10/17/2018	Guadalupe Creek	O. mykiss	18.15	112	900.226000319328
10/17/2018	Guadalupe Creek	O. mykiss	3.85	68	900.226000319393
10/17/2018	Guadalupe Creek	O. mykiss	5.05	79	900.226000319327
10/17/2018	Guadalupe Creek	O. mykiss	5.23	74	900.226000319362
10/17/2018	Guadalupe Creek	O. mykiss	11.22	90	900.226000319304
10/17/2018	Guadalupe Creek	O. mykiss	5.31	74	900.226000319398
10/18/2018	Alamitos Creek	O. mykiss	5.35	68	900.226000319284
10/18/2018	Alamitos Creek	O. mykiss	4.23	66	900.226000319260
10/18/2018	Alamitos Creek	O. mykiss	4.35	65	900.226000319291
10/18/2018	Alamitos Creek	O. mykiss	3.25	65	900.226000319292
10/18/2018	Alamitos Creek	O. mykiss	4.86	69	900.226000319295
10/18/2018	Alamitos Creek	O. mykiss	20.60	125	900.226000319250
10/18/2018	Alamitos Creek	O. mykiss	17.50	109	900.226000319246
10/18/2018	Alamitos Creek	O. mykiss	36.50	145	900.226000319258
10/18/2018	Alamitos Creek	O. mykiss	14.80	79	900.226000319263
10/18/2018	Alamitos Creek	O. mykiss	24.90	109	900.226000319201
10/18/2018	Alamitos Creek	O. mykiss	12.50	94	900.226000319218
10/18/2018	Alamitos Creek	O. mykiss	18.60	106	900.226000319269
10/18/2018	Alamitos Creek	O. mykiss	20.20	111	900.226000319200
10/18/2018	Alamitos Creek	O. mykiss	19.00	108	900.226000319311
10/18/2018	Alamitos Creek	O. mykiss	42.30	146	900.226000319257
10/18/2018	Alamitos Creek	O. mykiss	16.80	110	900.226000319290
10/22/2018	Alamitos Creek	O. mykiss	7.70	84	900.226000319343
10/22/2018	Alamitos Creek	O. mykiss	13.80	98	900.226000319306
10/22/2018	Alamitos Creek	O. mykiss	13.00	100	900.226000319349
10/22/2018	Alamitos Creek	O. mykiss	9.60	91	900.226000319312
10/22/2018	Alamitos Creek	O. mykiss	14.10	102	900.226000319315
10/22/2018	Alamitos Creek	O. mykiss	12.80	103	900.226000319382
10/22/2018	Alamitos Creek	O. mykiss	10.00	91	900.226000319365
10/22/2018	Alamitos Creek	O. mykiss	445.00	345	900.228000613703
10/22/2018	Alamitos Creek	O. mykiss	9.40	92	900.226000319363
10/22/2018	Alamitos Creek	O. mykiss	10.20	90	900.226000319390
10/22/2018	Alamitos Creek	O. mykiss	23.00	119	900.226000319378
10/22/2018	Alamitos Creek	O. mykiss	25.10	115	900.226000319396
10/22/2018	Alamitos Creek	O. mykiss	20.80	117	900.226000319368
10/22/2018	Alamitos Creek	O. mykiss	28.20	129	900.226000319380
10/23/2018	Calero Creek	O. mykiss	215.30	263	900.228000613704
10/23/2018	Calero Creek	O. mykiss	7.50	82	900.226000319280
10/23/2018	Calero Creek	O. mykiss	125.20	216	900.228000613705
10/23/2018	Calero Creek	O. mykiss	14.30	109	900.226000319268
10/23/2018	Calero Creek	O. mykiss	11.50	95	900.226000319336
10/23/2018	Calero Creek	O. mykiss	7.30	82	900.226000319302
10/23/2018	Calero Creek	O. mykiss	10.10	89	900.226000319332
10/23/2018	Calero Creek	O. mykiss	5.20	67	900.226000319373

10/24/2018	Calero Creek	O. mykiss	9.30	84	900.226000319357
10/24/2018	Calero Creek	O. mykiss	7.80	84	900.226000319347
10/24/2018	Calero Creek	O. mykiss	5.40	75	900.226000319323
10/24/2018	Calero Creek	O. mykiss	10.40	86	900.226000319300
10/24/2018	Calero Creek	O. mykiss	8.50	85	900.226000319231
10/24/2018	Calero Creek	O. mykiss	12.50	94	900.226000319244
10/24/2018	Calero Creek	O. mykiss	8.30	82	900.226000319287
10/24/2018	Calero Creek	O. mykiss	10.20	93	900.226000319230
10/24/2018	Calero Creek	O. mykiss	9.40	86	900.226000319212
11/6/2018	Guadalupe Creek	O. mykiss	12.40	95	900.226000319294
11/6/2018	Guadalupe Creek	O. mykiss	8.70	87	900.226000319214
11/6/2018	Guadalupe Creek	O. mykiss	18.20	116	900.226000319278
10/9/2019	Guadalupe Creek	O. mykiss	5.73	75	900.228000613710
10/9/2019	Guadalupe Creek	O. mykiss	6.60	84	900.226000319233
10/9/2019	Guadalupe Creek	O. mykiss	9.5	88	900.226000319239
10/9/2019	Guadalupe Creek	O. mykiss	7.1	81	900.226000319210
10/9/2019	Guadalupe Creek	O. mykiss	152.1	234	900.228000613711
10/9/2019	Guadalupe Creek	O. mykiss	5.1	71	900.226000319209
10/9/2019	Guadalupe Creek	O. mykiss	5.8	77	900.226000319277
10/9/2019	Guadalupe Creek	O. mykiss	9.6	85	900.226000319220
10/9/2019	Guadalupe Creek	O. mykiss	53.6	168	900.228000613712
10/9/2019	Guadalupe Creek	O. mykiss	14.7	104	900.226000319222
10/9/2019	Guadalupe Creek	O. mykiss	8.6	84	900.226000319228
10/9/2019	Guadalupe Creek	O. mykiss	8.0	76	900.226000319237
10/10/2019	Alamitos Creek	O. mykiss	11.4	95	900.226000319265
10/10/2019	Guadalupe Creek	O. mykiss	8.6	82	900.226000319288
10/10/2019	Guadalupe Creek	O. mykiss	8.6	86	900.226000319208
10/10/2019	Guadalupe Creek	O. mykiss	9.4	89	900.226000319252
10/10/2019	Guadalupe Creek	O. mykiss	3.4	66	900.226000319369
10/10/2019	Guadalupe Creek	O. mykiss	7.9	85	900.226000319249
10/10/2019	Guadalupe Creek	O. mykiss	41.7	150	900.226000319215
10/10/2019	Guadalupe Creek	O. mykiss	16.3	106	900.226000319204
10/10/2019	Guadalupe Creek	O. mykiss	6.5	82	900.226000319296
10/10/2019	Guadalupe Creek	O. mykiss	14.3	99	900.226000319261
10/10/2019	Guadalupe Creek	O. mykiss	7.1	81	900.226000319206
10/10/2019	Guadalupe Creek	O. mykiss	10.2	91	900.226000319242
10/10/2019	Guadalupe Creek	O. mykiss	7.7	81	900.226000319219
10/10/2019	Guadalupe Creek	O. mykiss	9.5	89	900.226000319216
10/10/2019	Guadalupe Creek	O. mykiss	10.4	91	900.226000319281
10/10/2019	Guadalupe Creek	O. mykiss	12.3	100	900.226000319217
10/10/2019	Guadalupe Creek	O. mykiss	16.5	107	900.226000319272
10/10/2019	Guadalupe Creek	O. mykiss	13.4	104	900.226000319247
10/23/2019	Alamitos Creek	O. mykiss	7.9	83	900.226000319254
10/23/2019	Alamitos Creek	O. mykiss	11.5	87	900.226000319203
10/23/2019	Alamitos Creek	O. mykiss	5.5	75	900.226000319205
10/23/2019	Alamitos Creek	O. mykiss	3.3	65	900.226000319225
10/23/2019	Alamitos Creek	O. mykiss	3.9	68	900.226000319282

10/23/2019	Alamitos Creek	O. mykiss	4.9	71	900.226000319224
10/23/2019	Alamitos Creek	O. mykiss	5.7	76	900.226000319248
10/23/2019	Alamitos Creek	O. mykiss	13.9	105	900.226000319221
10/23/2019	Alamitos Creek	O. mykiss	5.3	72	900.226000319226
10/23/2019	Alamitos Creek	O. mykiss	4.1	68	900.226000319202
10/23/2019	Alamitos Creek	O. mykiss	4.8	69	900.226000319223
10/23/2019	Alamitos Creek	O. mykiss	14.4	105	900.226000319236
10/23/2019	Alamitos Creek	O. mykiss	4.7	67	900.226000319240
10/23/2019	Alamitos Creek	O. mykiss	22.9	122	900.226000319274
10/23/2019	Alamitos Creek	O. mykiss	5.2	73	900.226000319283
10/23/2019	Alamitos Creek	O. mykiss	10.7	90	900.226000319273
10/23/2019	Alamitos Creek	O. mykiss	15.1	106	900.226000319256
10/23/2019	Alamitos Creek	O. mykiss	9.0	88	900.226000319211
10/28/2019	Calero Creek	O. mykiss	250.1	280	900.228000613713
10/28/2019	Calero Creek	O. mykiss	7.9	85	900.226000319259
10/28/2019	Calero Creek	O. mykiss	6.6	81	900.226000319297
10/28/2019	Calero Creek	O. mykiss	12.4	96	900.226000319285
10/28/2019	Calero Creek	O. mykiss	14.6	107	900.226000319286
10/28/2019	Calero Creek	O. mykiss	12.3	95	900.226000319207
10/28/2019	Calero Creek	O. mykiss	8.5	86	900.226000319245
10/30/2019	Guadalupe River	O. mykiss	169.6	248	900.228000613714
10/31/2019	Alamitos Creek	O. mykiss	7.0	81	900.226000319270
10/31/2019	Alamitos Creek	O. mykiss	12.2	99	900.226000319232
10/31/2019	Alamitos Creek	O. mykiss	28.8	134	900.226000319213
10/31/2019	Alamitos Creek	O. mykiss	11.7	95	900.226000319241
10/31/2019	Alamitos Creek	O. mykiss	5.8	75	900.226000319267
10/31/2019	Alamitos Creek	O. mykiss	10.7	90	900.226000319298
10/31/2019	Alamitos Creek	O. mykiss	6.3	76	900.226000319299
10/31/2019	Alamitos Creek	O. mykiss	13.4	98	900.226000319234
10/31/2019	Alamitos Creek	O. mykiss	11.6	93	900.226000319271
10/31/2019	Alamitos Creek	O. mykiss	11.5	95	900.226000319238
10/31/2019	Alamitos Creek	O. mykiss	11.9	99	900.226000319255
10/31/2019	Alamitos Creek	O. mykiss	8.5	90	900.226000319251
10/31/2019	Alamitos Creek	O. mykiss	15.9	103	900.226000319262
10/31/2019	Alamitos Creek	O. mykiss	25.4	130	900.226000319253
10/31/2019	Alamitos Creek	O. mykiss	12.0	96	900.226000319229
10/31/2019	Alamitos Creek	O. mykiss	14.1	97	900.226000319275
10/31/2019	Alamitos Creek	O. mykiss	20.2	115	900.226000319279
10/31/2019	Alamitos Creek	O. mykiss	33.6	140	982.126058146080
10/31/2019	Alamitos Creek	O. mykiss	18.9	112	982.126058146069
10/31/2019	Alamitos Creek	O. mykiss	19.5	117	982.126058146081
10/31/2019	Alamitos Creek	O. mykiss	15.1	105	982.126058146089
10/31/2019	Alamitos Creek	O. mykiss	6.6	80	982.126058146053
10/31/2019	Alamitos Creek	O. mykiss	65.4	173	900.228000613716
10/31/2019	Alamitos Creek	O. mykiss	281.8	280	900.228000613715
10/31/2019	Alamitos Creek	O. mykiss	60.3	170	900.228000613718
10/31/2019	Alamitos Creek	O. mykiss	40.1	150	900.228000613717

11/4/2019	Upper Penitencia	O. mykiss	5.2	74	982.126058146054
11/4/2019	Upper Penitencia	O. mykiss	6.0	76	982.126058146126
11/4/2019	Upper Penitencia	O. mykiss	7.0	79	982.126058146101
11/4/2019	Upper Penitencia	O. mykiss	9.3	89	982.126058146077
11/4/2019	Upper Penitencia	O. mykiss	75.1	189	900.228000613719
11/4/2019	Upper Penitencia	O. mykiss	17.8	111	982.126058146117
11/4/2019	Upper Penitencia	O. mykiss	15.1	108	982.126058146065
11/4/2019	Upper Penitencia	O. mykiss	9.9	94	982.126058146106
11/4/2019	Upper Penitencia	O. mykiss	9.1	88	982.126058146036
11/4/2019	Upper Penitencia	O. mykiss	96.5	209	900.228000613720
11/4/2019	Upper Penitencia	O. mykiss	151.3	236	900.228000613721
11/4/2019	Upper Penitencia	O. mykiss	-	-	900.228000613722
11/4/2019	Upper Penitencia	O. mykiss	12.4	97	982.126058146093
11/4/2019	Upper Penitencia	O. mykiss	7.8	85	982.126058146039
11/4/2019	Upper Penitencia	O. mykiss	11.3	93	982.126058146070
11/4/2019	Upper Penitencia	O. mykiss	63.9	177	900.228000613723
11/4/2019	Upper Penitencia	O. mykiss	5.1	74	982.126058146083
11/4/2019	Upper Penitencia	O. mykiss	59.4	178	900.228000613724
11/4/2019	Upper Penitencia	O. mykiss	13.8	105	982.126058146067
11/4/2019	Upper Penitencia	O. mykiss	8.5	84	982.126058146084
11/4/2019	Upper Penitencia	O. mykiss	-	79	982.126058146042
11/4/2019	Upper Penitencia	O. mykiss	24.1	130	982.126058146043
11/4/2019	Upper Penitencia	O. mykiss	-	106	982.126058146105
11/4/2019	Upper Penitencia	O. mykiss	12	92	982.126058146111
11/4/2019	Upper Penitencia	O. mykiss	4.5	73	982.126058146044
11/4/2019	Upper Penitencia	O. mykiss	7.6	84	982.126058146100
11/4/2019	Upper Penitencia	O. mykiss	17.3	108	982.126058146116
11/4/2019	Upper Penitencia	O. mykiss	48.2	162	900.228000613726
11/4/2019	Upper Penitencia	O. mykiss	10.8	92	982.126058146058
11/4/2019	Upper Penitencia	O. mykiss	41.1	158	900.228000613727
11/4/2019	Upper Penitencia	O. mykiss	8.7	91	982.126058146085
11/4/2019	Upper Penitencia	O. mykiss	5.2	73	982.126058146095
11/4/2019	Upper Penitencia	O. mykiss	7.2	85	982.126058146103
11/4/2019	Upper Penitencia	O. mykiss	15.5	103	982.126058146046
11/4/2019	Upper Penitencia	O. mykiss	10.7	100	982.126058146074
11/4/2019	Upper Penitencia	O. mykiss	5.8	78	982.126058146076
11/4/2019	Upper Penitencia	O. mykiss	41.9	156	900.228000613728
11/4/2019	Upper Penitencia	O. mykiss	38.6	145	982.126058146034
11/4/2019	Upper Penitencia	O. mykiss	49.2	162	900.228000613730
11/4/2019	Upper Penitencia	O. mykiss	12.5	101	982.126058146096
11/4/2019	Upper Penitencia	O. mykiss	6.2	78	982.126058146055
11/4/2019	Upper Penitencia	O. mykiss	13.3	96	982.126058146033
11/4/2019	Upper Penitencia	O. mykiss	8.7	88	982.126058146037
11/4/2019	Upper Penitencia	O. mykiss	6.9	83	982.126058146063
11/4/2019	Upper Penitencia	O. mykiss	13.1	102	982.126058146071
11/4/2019	Upper Penitencia	O. mykiss	143.1	234	900.228000613729
11/4/2019	Upper Penitencia	O. mykiss	5.8	75	982.126058146129

11/4/2019	Upper Penitencia	O. mykiss	19.7	112	982.126058146064
11/4/2019	Upper Penitencia	O. mykiss	55.3	172	900.228000613731
11/4/2019	Upper Penitencia	O. mykiss	11.5	98	982.126058146079
11/4/2019	Upper Penitencia	O. mykiss	19.2	112	982.126058146068
11/4/2019	Upper Penitencia	O. mykiss	6.2	79	982.126058146092
11/4/2019	Upper Penitencia	O. mykiss	7.9	86	982.126058146056
11/4/2019	Upper Penitencia	O. mykiss	5.3	77	982.126058146087
11/4/2019	Upper Penitencia	O. mykiss	6.3	81	982.126058146048
11/4/2019	Upper Penitencia	O. mykiss	8.7	90	982.126058146062
11/4/2019	Upper Penitencia	O. mykiss	6.3	78	982.126058146041
11/4/2019	Upper Penitencia	O. mykiss	13.9	101	982.126058146098
11/4/2019	Upper Penitencia	O. mykiss	5.5	77	982.126058146113
11/4/2019	Upper Penitencia	O. mykiss	5.1	74	982.126058146115
11/4/2019	Upper Penitencia	O. mykiss	8.6	90	982.126058146088
11/4/2019	Upper Penitencia	O. mykiss	171.5	245	900.228000613732
11/6/2019	Coyote Creek	O. mykiss	18.1	112	982.126058146078
11/6/2019	Coyote Creek	O. mykiss	23.2	122	982.126058146114
11/6/2019	Coyote Creek	O. mykiss	28.2	133	982.126058146107
11/13/2019	Upper Penitencia	O. mykiss	31.8	141	982.126058146110
11/13/2019	Upper Penitencia	O. mykiss	10.6	95	982.126058146131
11/13/2019	Upper Penitencia	O. mykiss	38.8	153	900.228000613734
11/13/2019	Upper Penitencia	O. mykiss	24.8	128	982.126058146118
11/13/2019	Upper Penitencia	O. mykiss	20.4	125	982.126058146082
11/13/2019	Upper Penitencia	O. mykiss	58.2	172	900.228000613735
11/13/2019	Upper Penitencia	O. mykiss	54.7	168	900.228000613736
11/13/2019	Upper Penitencia	O. mykiss	35.2	149	982.126058146075
11/13/2019	Upper Penitencia	O. mykiss	147.8	238	900.228000613738
11/13/2019	Upper Penitencia	O. mykiss	46.3	159	900.228000613739
11/13/2019	Upper Penitencia	O. mykiss	23.5	124	982.126058146102
11/13/2019	Upper Penitencia	O. mykiss	96.5	204	900.228000613737
11/13/2019	Upper Penitencia	O. mykiss	68.9	184	900.228000613740
11/13/2019	Upper Penitencia	O. mykiss	119.5	224	900.228000613742
11/13/2019	Upper Penitencia	O. mykiss	7.5	84	982.126058146051
11/13/2019	Upper Penitencia	O. mykiss	7.5	86	982.126058146038
11/13/2019	Upper Penitencia	O. mykiss	30.5	140	982.126058146123
11/13/2019	Upper Penitencia	O. mykiss	9.8	88	982.126058146057
11/13/2019	Upper Penitencia	O. mykiss	12.2	97	982.126058146032
11/13/2019	Upper Penitencia	O. mykiss	8.7	80	982.126058146073
11/13/2019	Upper Penitencia	O. mykiss	23.6	125	982.126058146047
11/13/2019	Upper Penitencia	O. mykiss	15.7	94	982.126058146122
11/13/2019	Upper Penitencia	O. mykiss	13.8	94	982.126058146049
11/13/2019	Upper Penitencia	O. mykiss	9.1	86	982.126058146109
11/13/2019	Upper Penitencia	O. mykiss	8.8	84	982.126058146052
11/13/2019	Upper Penitencia	O. mykiss	24.5	124	982.126058146099
11/13/2019	Upper Penitencia	O. mykiss	26.3	128	982.126058146128
11/13/2019	Upper Penitencia	O. mykiss	73.5	184	900.228000613743
11/13/2019	Upper Penitencia	O. mykiss	38.5	134	982.126058146124

11/13/2019	Upper Penitencia	O. mykiss	2.9	84	982.126058146045
11/13/2019	Upper Penitencia	O. mykiss	110.3	209	900.228000613744
11/13/2019	Upper Penitencia	O. mykiss	28.9	132	982.126058146108
11/13/2019	Upper Penitencia	O. mykiss	12.4	96	982.126058146090
11/13/2019	Upper Penitencia	O. mykiss	37.2	154	982.126058146059

Guadalupe River Watershed *Oncorhynchus mykiss* Migration Monitoring Using Passive Integrated Transponder Tags: Pilot Study



Prepared by:

Valley Water

Environmental Mitigation and Monitoring Unit

January 30, 2020

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INTRODUCTION

The Guadalupe River Watershed begins in headwater tributaries near the summits of Loma Prieta and Mount Umunhum, draining the eastern Santa Cruz Mountains of Santa Clara County to the west, then north into the mainstem of the Guadalupe River that flows into South San Francisco Bay through Alviso Slough. Major tributaries in the Guadalupe River Watershed include Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek. Steelhead (*Oncorhynchus mykiss; O. mykiss* for the remainder of the document) in the Central California Coast (CCC) Distinct Population Segment, persist in these systems. In fall 2018, Valley Water conducted juvenile *O. mykiss* sampling at 23 stations in the Guadalupe River Watershed, including stations in the Guadalupe River, Guadalupe Creek, Los Gatos Creek, Calero Creek, and Alamitos Creek. Multipass depletion backpack electrofishing was conducted at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Guadalupe River Watershed. One hundred and twenty-five, appropriately sized *O. mykiss* were tagged with passive integrated transponder (PIT) tags to study their movement within the Guadalupe River Watershed (Valley Water 2019).

A PIT tag is a small passive radio frequency transponder that contains a unique code, which allows researchers to tag fish with distinctive identifying codes. As mentioned in the name of these tags, they are passive. They do not require a battery to produce a signal, the signal is generated by a radio-frequency identification (RFID) system that sends a radio frequency into the environment. When a tag is detected by the system, information is relayed from the tag to the system where information on date and time is recorded. In the Guadalupe River Watershed, stationary tag reading systems were deployed in three locations in the watershed. This allowed for movement of *O. mykiss* to be detected as fish passed over the antenna and potentially out-migrated to the ocean.

The goal of this pilot study was to assess the feasibility of conducting a PIT movement and migration study in the Guadalupe River Watershed, as well as to gain a better understanding of juvenile migratory timing and behavior. Additionally, this study will hopefully reveal which portions of the population are showing migratory tendencies.

2.0 METHODS

2.1 Fish PIT Tagging

O. mykiss were PIT tagged during the Valley Water 2018 juvenile rearing monitoring conducted between October and November 2018 (Valley Water 2019). Fish with a fork-length of 65 mm or greater were tagged during this exercise. *O. mykiss* with a fork-length greater than or equal to 65 mm but with less than a 150 mm fork-length received 12 mm half-duplex PIT tags. *O. mykiss* with a fork-length of 150 mm or greater received 23 mm half-duplex PIT tags (Figure 2). PIT tag numbers and associated biological data

for all fish tagged by Valley Water in Santa Clara County are included in Appendix A. All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure.

A total of 125 *O. mykiss* were tagged in the Guadalupe River Watershed in 2018: 58 on Alamitos Creek, 50 on Guadalupe Creek, and 17 on Calero Creek. No *O. mykiss* were tagged on Los Gatos Creek or the Guadalupe River. Tagging locations are displayed in Figure 1. *O. mykiss* were previously tagged in the Guadalupe River Watershed in 2013 and 2014 (Hobbs 2014). However, it is unlikely any of these fish would still be present in the system, but the tag numbers were referenced when determine tag origin.

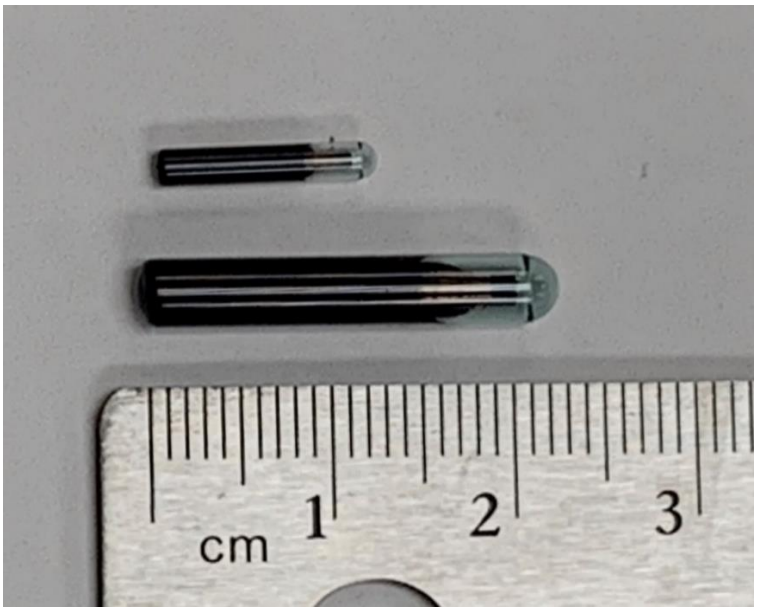


Figure 1: Twelve and 23 mm half duplex PIT tags.



Figure 2: *O. mykiss* PIT tagging stations from the 2018 juvenile O. mykiss rearing study in the Guadalupe River Watershed.

2.2 Antenna Construction and Operation

All three of the antennas installed used half duplex RFID technology. The basic components of the half duplex arrays consisted of an RFID reader, a power source, a tuning capacitor, and an antenna (http://www.oregonrfid.biz/). When readers detect a PIT tag they store the following detection data: PIT tag number, date and time stamp, number of times tag was detected, and number of scans since last detection. Details on each antenna are provided below. Detections recorded by the antenna indicate proximity to the antenna at a given time. The antennas do not indicate direction of movement. Assumptions must be made about direction based on the release point after tagging occurs and the position of the antenna in the Watershed. Assumptions are also made that detections are of the target species, and not tags that have been expelled and are mobile in the system, or are in digestive system of a predatory species. Specific locations of the antenna are not provided to reduce the potential of vandalism and theft.

2.2.0 Alamitos Creek

The Alamitos Creek antenna was installed on November 26, 2018. This antenna is located downstream of the Calero Creek confluence, so it will detect potential outmigration that is occurring from both the Calero and Alamitos Creeks subwatershed. This antenna is approximately 10 m long by 0.4 m wide, with a swim-over design and was installed directly into a man-made groove in a wood vortex weir (Figure 1). This weir was installed as part of the Valley Water Stream Maintenance Program (SMP) Alamitos Creek Instream Habitat Complexity Project. This project consisted of the implementation of large woody structures and a gravel augmentation. The antenna used a single loop of 8 American wire gauge (AWG) copper wire, passed through a plastic conduit, imbedded in the groove of the log. Plastic strappings and ceramic covered screws were used to secure the conduit in attempt to reduce electrical noise and interference caused by metal in close proximity to the antenna. Between November 26, 2018 and January 7, 2019, this antenna was powered by two 12-volt deep cycle batteries linked in parallel to achieve desired voltage output. Batteries were replaced with fully charged batteries every seven days. On January 7, 2019, a 120-volt wired receptacle was installed and a 12-volt power inverter was connected. This eliminated the need for battery swaps as constant power was available.



Figure 3: Swim-over antenna at Alamitos Creek installed in a groove of the wood vortex weir.

The antenna provided complete lateral coverage of the channel during winter base flows, but during storm events areas along the channel margin were not within a detectable range of the antenna. The read ranges for PIT tags directly above the antenna were typically 15-20 cm for 12 mm PIT tags and 30 cm for 23 mm PIT tags. The read range up and downstream of the antenna was typically 3 cm and 15 cm for the 12 mm and the 23 mm tag respectively. Outages occurred as a result of battery outages, high flows flooding tuner and reader boxes, and damage to electrical connections (Table 1). Damage occurred to the antenna in March, that took significant time to troubleshoot. On April 8, 2019, a 10.0 m long by 0.90 m tall, single loop of 10 AWG wire, swim-through antenna was installed just downstream of the original swim-over antenna in attempt to reduce a lapse in data collection. This antenna had limited read range but had the potential to detected tags that passed within approximately 4 and 8 cm of the antenna for 12 mm and 23 mm PIT tags respectively. This antenna was removed after troubleshooting and repairs were made to the swim-over antenna on April 22, 2019 (Table 1).

Estimates of the portion of the water column effectively scanned were made using measured read range and outputs from HEC-RAS modeling in the Alamitos Creek subwatershed. The crest of the log structure that the antenna was installed in was considered to be geomorphologically similar to a riffle crest in the Alamitos Creek System. Based on the modeling results it is estimated that the Alamitos Creek swim-over antenna provided complete coverage of the entire water column up to a flow of 13

cubic feet per second (cfs; flow measurements will be reported using the standard unit system) for 12 mm tags and 23 cfs for 23 mm tags (Figure 4). Detections can still occur at higher flows, as shown by the data, but efficiency decreases at flows above those listed above.

Table 1: Alamitos Creek antenna recorded outage duration and outage type during the monitoring period.

Outage Type	**Outage Start**	**Outage End**
Complete	12/25/2018 04:00	12/26/2018 10:26
Complete	1/14/2019 Unknown Time	1/18/2019 14:30
Complete	2/12/2019 Unknown Time	2/21/2019 15:17
Reduced Read Range	3/11/2019 Unknown Time	3/20/2019 15:03
Reduced Read Range	3/25/2019 Unknown Time	4/22/2019 16:15
Date and time of outage is often unknown as log files do not record all potential outage types.		

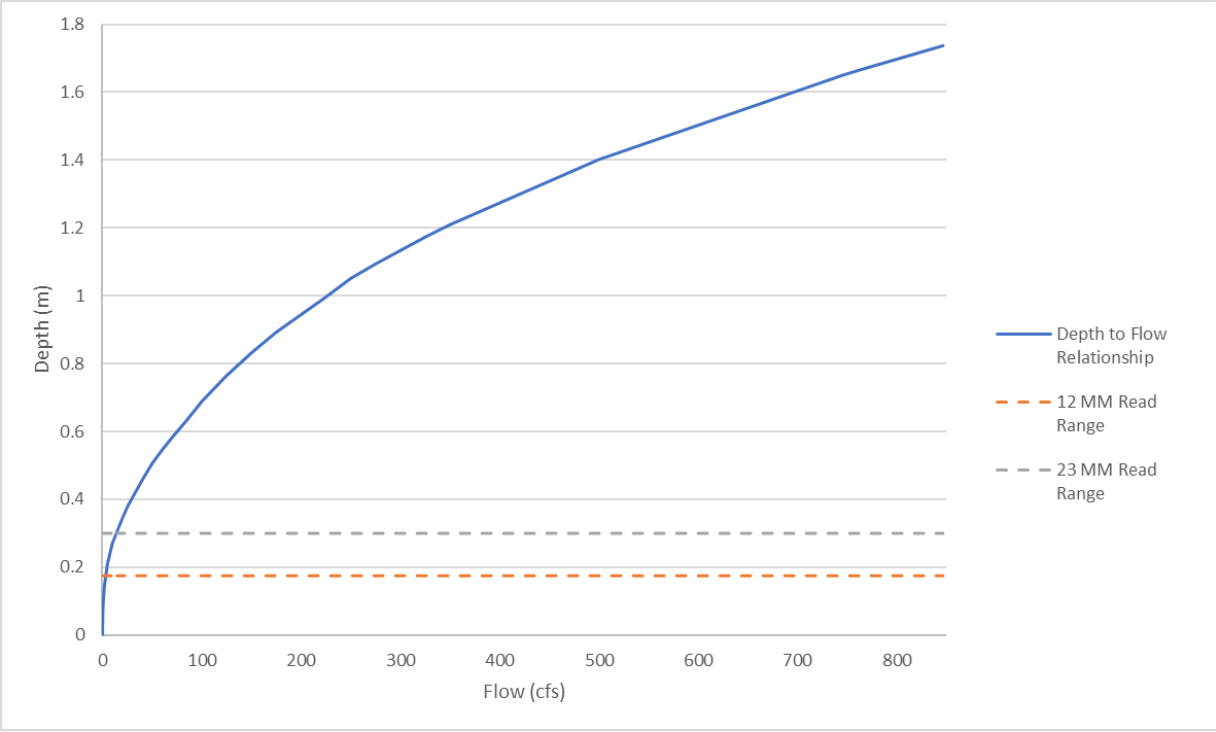


Figure 4: Depth to flow cross sectional analysis overlaid with read range at the Alamitos Creek Antenna. Read range of 12 mm and 23 mm tags was the average read range detected.

2.2.1 Guadalupe Creek

The Guadalupe Creek antenna was installed upstream of the confluence with Guadalupe River on December 5, 2018. This antenna is a 10.3 m by 0.9 m, swim-through design, using a static line ratchet strapped between two anchoring points as the top support and stakes in the substrate to maintain contact with the bottom of the channel (Figure 2). The antenna uses a single loop of 10 AWG copper wire. The wire was not incased in a conduit and was connected to the static line and stakes in the bottom of the channel with plastic zip-ties. Between December 5, 2018 and May 24, 2019, this antenna was powered by two 12-volt deep cycle batteries linked in parallel to increase run time. Batteries were replaced with fully charged batteries every seven days. On May 24, 2019, a 120-volt wired receptacle was installed and a 12-volt power inverter was connected. This eliminated the need for battery swaps as constant power was available.



Figure 5: Swim-through antenna at Guadalupe Creek. The single loop of wire is difficult to see in the image.

The antenna provided complete lateral coverage of the channel during most flows, but during large storm events, when the floodplain inundated areas along the channel margin did not receive coverage. The read ranges typically spanned the entire height of

the antenna between the wires for both the 12 mm and 23 mm tags. On occasion, there was a small dead zone (less than 10 cm) in the middle of the antenna using the 12 mm tag. The read range up and downstream of the antenna was typically 3 cm and 10 cm for the 12 mm and the 23 mm tag respectively. The read range above the antenna was 30 cm for the 23 mm tag but reduced to 18 cm for the 12 mm tags. Outages occurred as a result of battery outages, high flows dismantling the antenna, and damage to electrical connections (Table 2).

Table 2: Guadalupe Creek antenna recorded outage duration and outage type during the monitoring period.

Outage Type	**Outage Start**	**Outage End**
Complete	1/14/2019 Unknown Time	1/18/2019 11:03
Complete	1/23/2019 10:27	1/25/2019 16:09
Complete	2/14/2019 8:58	2/20/2019 16:45
Complete	4/14/2019 20:00	4/15/2019 12:43
Date and time of outage is often unknown as log files do not record all potential outage types.		

Estimates of the portion of the water column effectively scanned were made using measured read range and outputs from HEC-RAS modeling in the Guadalupe Creek subwatershed. The antenna was installed within a riffle so the nearest cross section at a riffle crest was used as reference. Based on the modeling results it is estimated that the Guadalupe Creek swim-through antenna provided complete coverage of the entire water column above the antenna up to 543 cfs for 12 mm tag and complete coverage at any modeled flow for 23 mm tags (Figure 6). This does not account for horizontal inundation of the channel outsize the read range of the antenna.

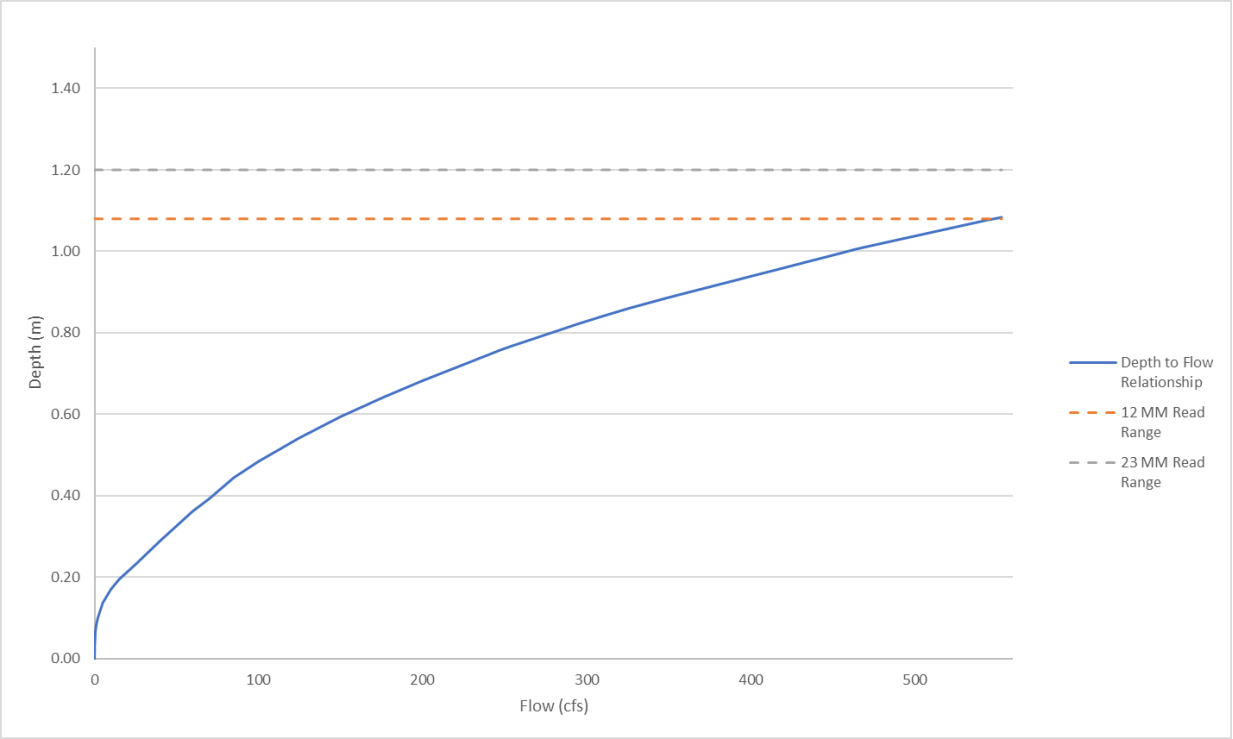


Figure 6: Depth to flow cross sectional analysis overlaid with read range at the Guadalupe Creek Antenna

2.2.2 Guadalupe River

The Guadalupe River antenna array was installed in the lower portion of the Guadalupe River on January 24, 2019 (Figure 7). This antenna consisted of two 3.0 m long by 0.9 m wide swim-over design, with two loops of 10 AWG wire, spaced using corrugated greenhouse plastic (approximately 1.5 cm apart). The wire was housed within a 3.8 cm diameter polyvinyl chloride (PVC) pipe. Two antennas were used to cover the width of the channel to gain the most efficient read range possible. The antennas were installed end to end in order to span the entire channel width, over a Sakrete structure using concrete anchors and ratchet straps. Antennas were given a specific identification (A1 and A2). The array used two single RFID readers in a “master/slave” configuration. This provided an alternating pulse of the electrical field to ensure that antennas were not canceling each other’s pulse. The two antennas were powered by four 12-volt deep cycle batteries linked in parallel to increase run time. Batteries were replaced with fully charged batteries every seven days.



Figure 7: Swim-over antenna at the Guadalupe River.

The antennas provided complete lateral coverage during winter base flows, but during large storm events, when the floodplain inundated and water depths increased, significant areas along the channel margin and the complete water column did not receive coverage. During high flows the antenna was only estimated to cover 30% of the lateral distance across the channel. The read ranges were typically 18 cm for the 12 mm tags and 30 cm for 23 mm tags. Outages occurred due to battery outages, vandalism, and damage to electrical connections during high flows (Table 3).

Table 3: Guadalupe River antenna recorded outage duration, antenna affected by outage, and outage type during the monitoring period.

Outage Type	**Antenna #**	**Outage Start**	**Outage End**
Complete	A2	4/29/2019 Unknown Time	5/8/2019 14:33
Complete	A1 and A2	5/20/2019 Unknown Time	5/22/2019 14:13
Date and time of outage is often unknown as log files do not record all potential outage types.			

Estimates of the portion of the water column effectively scanned were made using measured read ranges and outputs from HEC-RAS modeling in the Guadalupe River. The antenna was installed at a cross section that was previously measured for the model in the Guadalupe River. Based on the modeling results it is estimated that the Guadalupe River swim-over antenna provided complete coverage of the entire water column above the antenna to a flow of 91 cfs for 23 mm tags and 64 cfs for 12 mm tags (Figure 8).

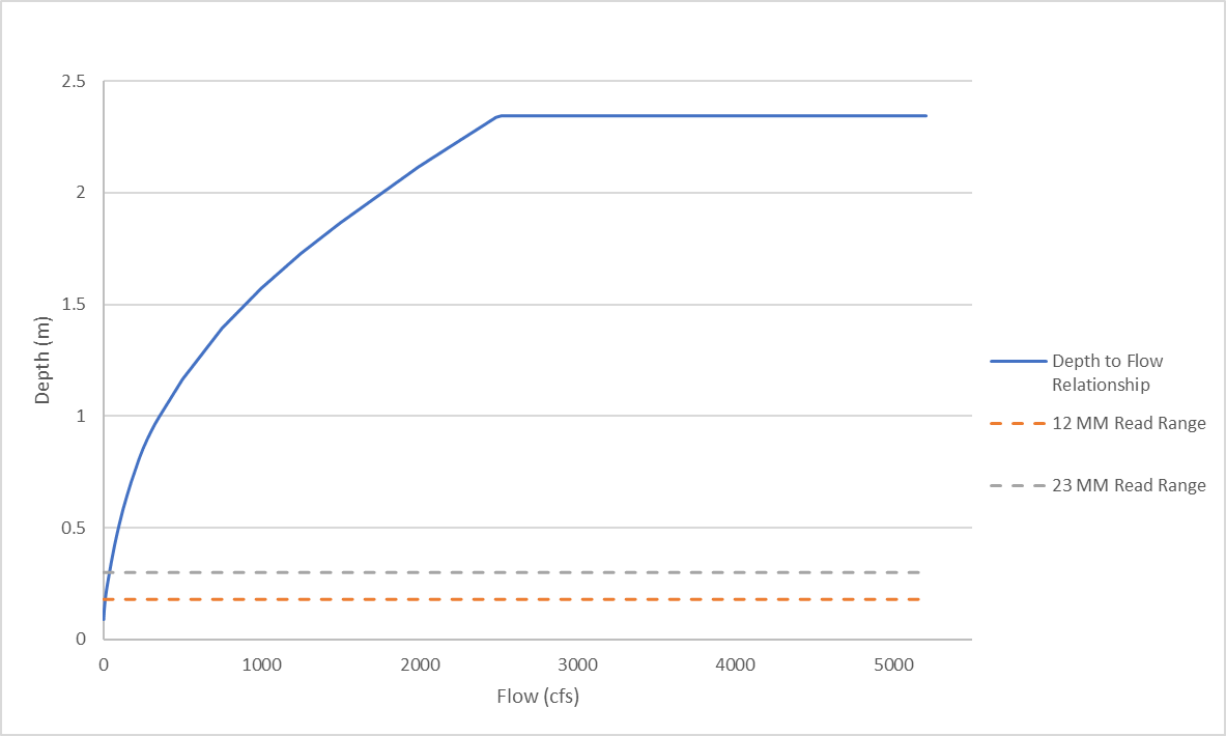


Figure 8: Modeled depth to flow relationship overlaid with read range of the 12 and 23 mm PIT tags at the Guadalupe River Antenna location.

3.0 RESULTS AND DISCUSSION

The monitoring reported is for the 2018-2019 migration season. Results included below contain data from the date of installation of the antenna to May 31, 2019.

3.1 Alamitos Creek Results and Discussion

O. mykiss were tagged at five locations on Alamitos Creek and 3 locations on Calero Creek. One tagging location was at the Alamitos PIT antenna site, prior to the installation of the antenna. These fish were tagged then released downstream of the antenna location. Assumption on direction of movement of these fish will be difficult to ascertained as movement upstream could have occurred prior to the time the antenna

was operational. A total of seven individual tags implanted in *O. mykiss* were detected at this station (Table 4). Five of the tags detected were from *O. mykiss* tagged in the Alamitos Creek subwatershed, one was from the Guadalupe Creek subwatershed, and one was from the Pescadero Creek Watershed (San Mateo County), tagged in the Pescadero Lagoon. *O. mykiss* from Alamitos Creek were detected from the most upstream station as well as the most downstream. Fish movement was not limited by position in the watershed (Figure 9).

Table 4: *O. mykiss* tag number and associated information of each fish detected at the Alamitos Creek antenna.

Date Tagged	Tag ID	Creek	Tagging Station	Length (FL)
8/15/2018	982.000365410929	Pescadero Creek	Pescadero Lagoon	170
9/17/2018	900.226000319316	Alamitos Creek	Mazzone	104
9/17/2018	900.226000319391	Alamitos Creek	Mazzone	138
9/17/2018	900.226000319355	Alamitos Creek	Mazzone	248
10/17/2018	900.226000319325	Guadalupe Creek	GC003	69
10/18/2018	900.226000319284	Alamitos Creek	AC004	68
10/22/2018	900.226000319382	Alamitos Creek	AC002	103

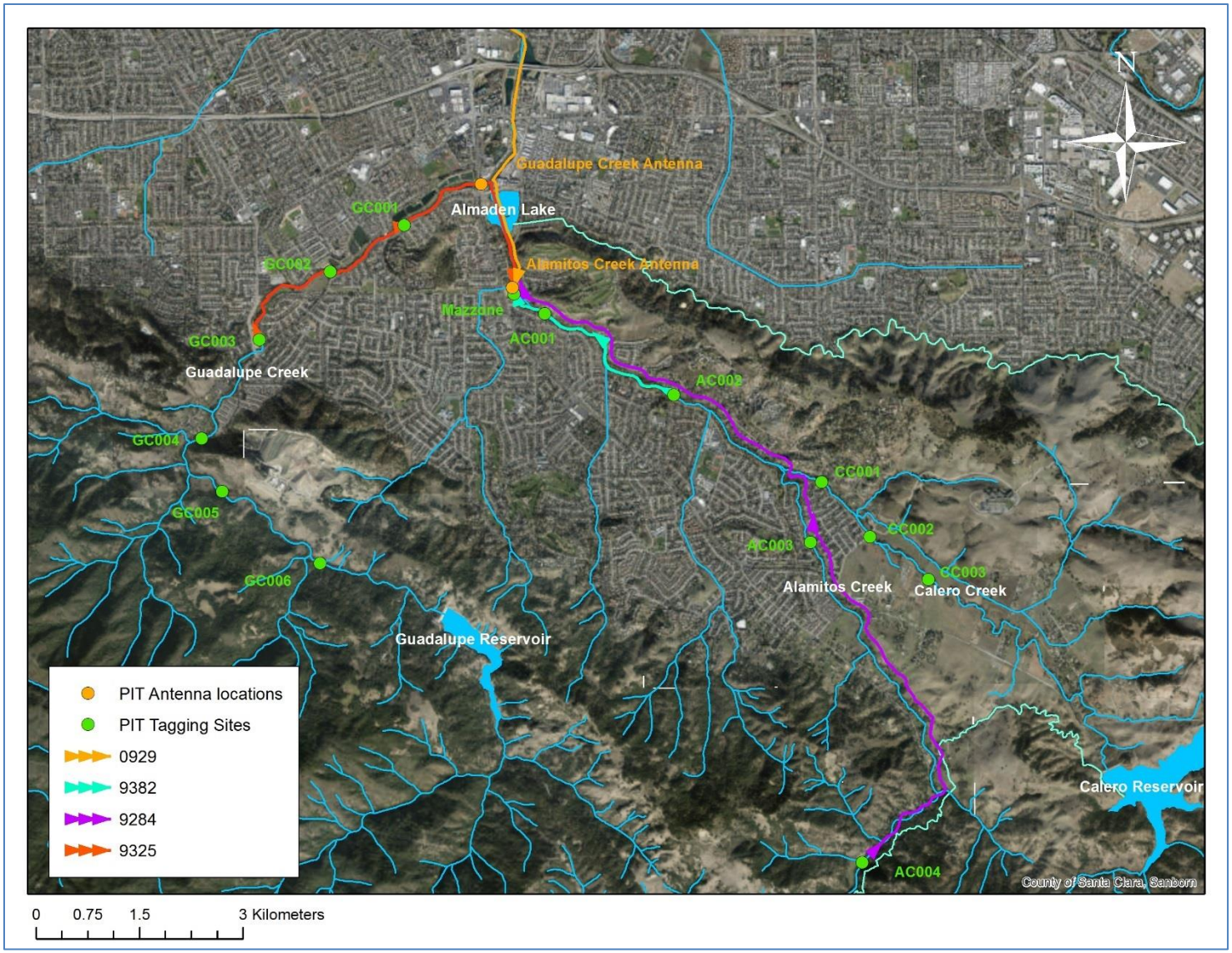


Figure 9: *O. mykiss* tagging locations and relative path to Alamitos Creek antenna. Fish tagged at the Mazzone station were not included on the map as they were released in close proximity to the Alamitos Creek antenna location.

Some of the *O. mykiss* detected were recorded multiple times on different days. The 248 mm fork-length fish tagged at the Mazzone station was repeatedly detected and appeared to be utilizing the restored habitat. This fish was tracked on 33 days between November 26, 2018 and May 31, 2019. This fish did not appear to have migratory tendencies and was detected well after the migration period in summer 2019. All other fish detected were recorded for only one to two days during the monitoring period. These fish were likely out-migrating or showing other migratory tendencies. The fish tagged in the Guadalupe Creek subwatershed was not detected out-migrating from Guadalupe Creek at the Guadalupe Creek antenna. It is not known if the fish migrated into Alamitos Creek prior to the installation of the antenna, and then was out-migrating or if it was detected during its initial run into the system, or if it was within a predator. At some point, the Guadalupe Creek tag moved out of Guadalupe Creek, successfully navigated the instream impoundment of Almaden Lake and made its way into Alamitos Creek. As with all detections, it is uncertain if the tagged *O. mykiss* from Pescadero Lagoon was the live fish that was originally tagged or if predation occurred and it was brought into the watershed. A Chinook salmon (*Oncorhynchus tshawytscha*) was detected by the automated fish counting system installed in the Guadalupe River downstream of the Alamitos Antenna just over three days prior to the first detection of the tag (Valley Water 2020). Chinook salmon are a potential predator of *O. mykiss,* especially while in the ocean. At some point, the Pescadero Lagoon tag (#0929) traveled the estimated 155 km trip from the Lagoon into the Alamitos Creek system. This tag was not detected at any other point of the migration season. There is also a potential that this tag was brought into the watershed by a bird but based on the detection rate (number of detections recorded per second) it seems more likely the detection was from a passing fish than a perching bird.

Movement of *O. mykiss* at the Alamitos Creek antenna was often associated with flow events (Figure 9). All detections occurred at under 145 cfs. It is unknown if the detection efficiency declines at that point or if fish are not moving during higher magnitude flows. Early season movement between November and December appeared to occur around small storm events, but it is not certain if this movement was migratory or local movement. Since the antenna does not provide information on fish direction, and the antenna was not operational when the fish were tagged, it is difficult to ascertain *O. mykiss* direction. Aside from movement associated with fish #0355 which appeared to be resident, detections of other *O. mykiss* indicated migratory behavior. Movement in January, March, and April following the declining limb of the hydrograph indicates likely migratory behaviors. No detections occurred in February, but the antenna experienced a 10-day outage during a large declining limb of the hydrograph. The low efficiency during the March and April timeframe limited the ability to detect fish. The presence of detections before and after the low efficiency period indicate that fish were likely

missed. The antenna also shows that there is potential movement of *O. mykiss* between different watershed and subwatersheds.

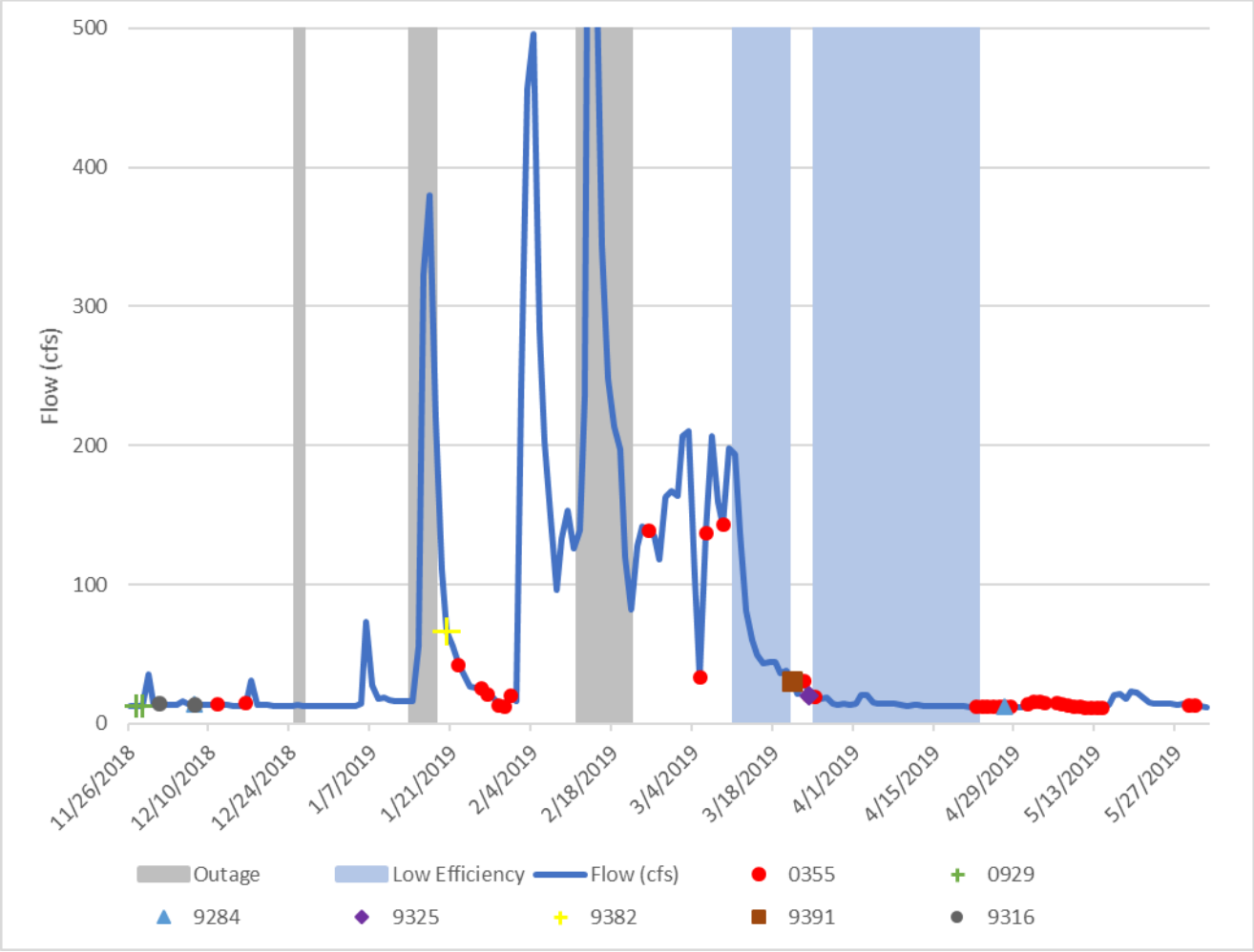


Figure 10: *O. mykiss* tracked on Alamitos Creek compared to flow on Alamitos Creek at Greystone (ALERT 5070) Stream Gage and antenna outages. (Peak flow removed from graph for better visual representation of tracked *O. mykiss*. Peak flow was 1000 cfs). Numbers in legend indicate last four digits of O. mykiss PIT tag number.

The repeated detection of *O. mykiss* #0355 provides evidence of the success of the SMP Alamitos Creek Instream Habitat Complexity project. The detections of *O. mykiss* #0355 shows fish are utilizing the habitat within the first year of construction in a wide range of flows.

The *O. mykiss* detected ranged between 68 and 248 mm fork-length when tagged. These lengths were recorded up to six months prior to the detection date, so the detected fish were likely larger than when they were initially tagged. The 248 mm fish

was the expected size of a resident *O. mykiss* and it displayed resident tendencies. The fish showing migratory tendencies tracked at the Alamitos Creek Antenna were between a 68 and 123 mm fork-length when tagged. According to Moyle (2002), in small streams with low summer flows, like the Guadalupe River Watershed, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith and Leicester (2016) aged 32 fish from Guadalupe Creek and found that young-of-the-year *O. mykiss* ranged from 85–114 mm, and fish in their second year ranged from 110–195 mm. This is a faster growth rate than predicted by Moyle (2002), but this is expected in warmer, more productive systems. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, *O. mykiss* detected by the Alamitos Creek antenna showing migratory tendencies were potentially at the end of their first and second years.

3.2 Guadalupe Creek Results and Discussion

O. mykiss were tagged at six locations on Guadalupe Creek. The Guadalupe Creek antenna was located at the very downstream end of the system, with less than 100 m of habitat before the confluence with the Guadalupe River. The habitat downstream of the antenna is not conducive to rearing. Assumption on direction of movement of these fish is easier to conclude as it is not likely these fish would be using the habitat downstream of the antenna. A total of six individual tags implanted in *O. mykiss* were detected at this station (Table 4). All of the tags were from fish tagged in the Guadalupe Creek subwatershed. All of the fish detected were recorded for one to two days during the sampling period. When fish were detected for more than one day, the detections occurred in consecutive days. These fish likely were out-migrating or showing other migratory tendencies. Fish movement was not limited by position in the watershed. *O. mykiss* from all but one tagging station were detected out-migrating (Figure 11).

Table 5: *O. mykiss* tag number and associated information of each fish detected at the Guadalupe Creek antenna.

Date Tagged	Tag ID	Creek	Tagging Station	Length (FL)
10/16/2018	900.226000319345	Guadalupe Creek	GC004	79
10/16/2018	900.226000319364	Guadalupe Creek	GC005	86
10/16/2018	900.226000319308	Guadalupe Creek	GC005	65
10/17/2018	900.226000319342	Guadalupe Creek	GC003	76
11/6/2018	900.226000319214	Guadalupe Creek	GC002	87
11/6/2018	900.226000319294	Guadalupe Creek	GC001	95

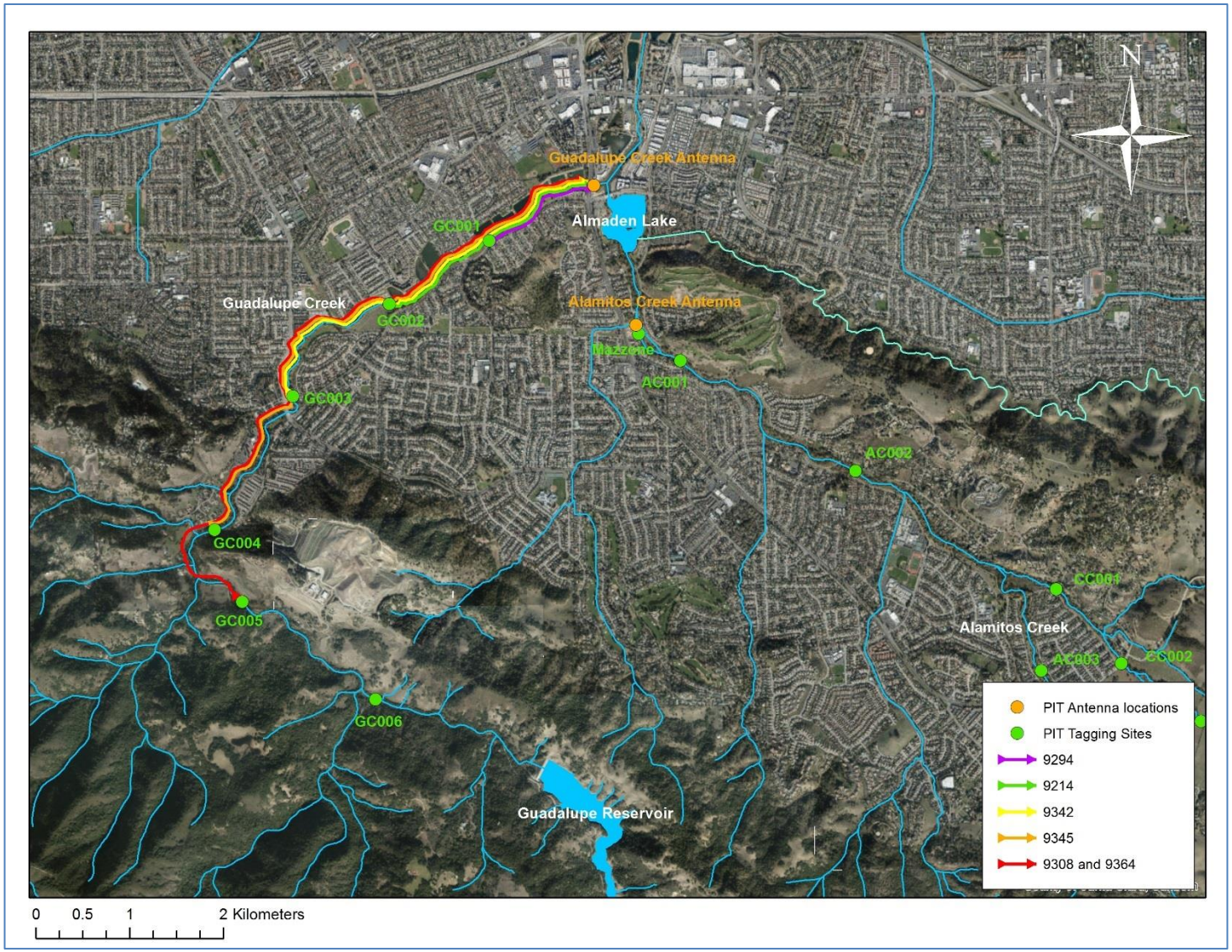


Figure 11: *O. mykiss* tagging locations in Guadalupe Creek and relative path to the Guadalupe Creek antenna for each fish.

Movement of *O. mykiss* was not detected until January after the first large storm event (Figure 12). Movement was associated with the declining limb of the hydrograph, except for one instance during an ascending portion. All movement was detected when flows were less than 70 cfs. It is not certain if 70 cfs is the threshold for movement or if the detection rate decreases at this flow. Movement in Guadalupe Creek occurred January through March. A large portion of a declining limb after a large storm event in February was missed due to an antenna outage. The fish tagged in Guadalupe Creek that was detected in Alamitos Creek was not detected by the Guadalupe Creek Antenna. This fish could have moved prior to the installation of the antenna or it was not detected as it out-migrated.

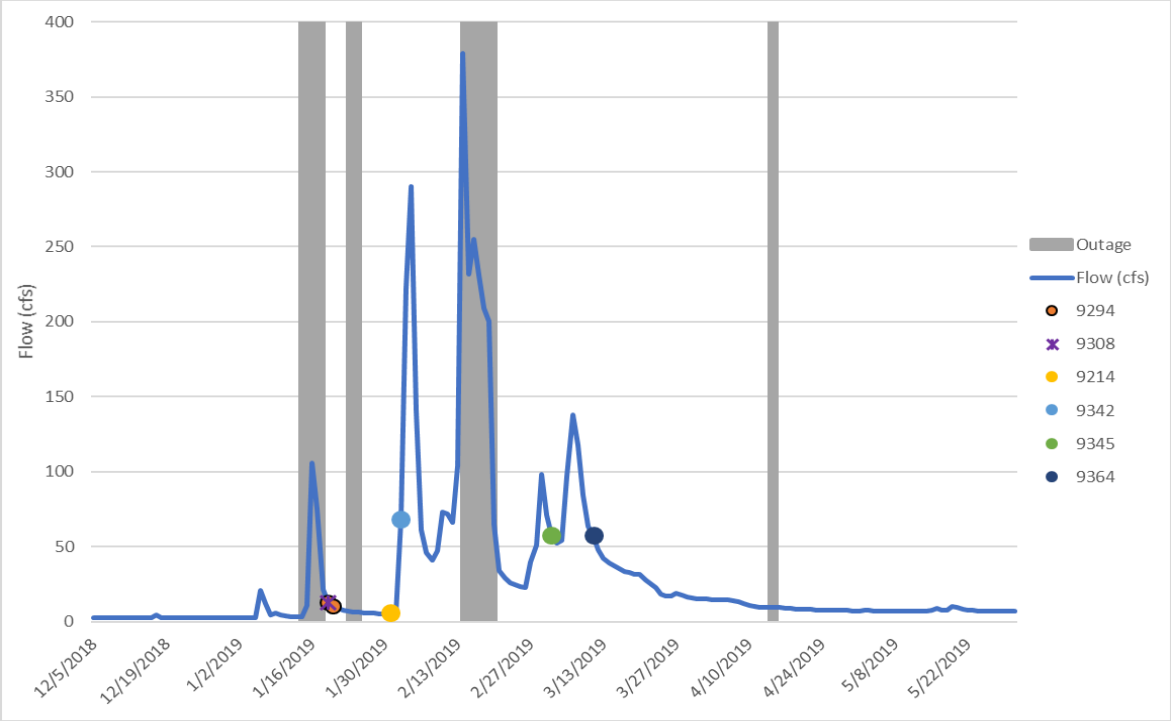


Figure 12: *O. mykiss* tracked on Guadalupe Creek compared to flow on Guadalupe Creek at Hicks Road (ALERT 5043) Stream Gage and antenna outages. Numbers in legend indicate the last four digits of *O. mykiss* PIT tag numbers.

The *O. mykiss* detected in Guadalupe Creek ranged between 65 and 95 mm fork-length when tagged. These lengths were recorded up to five months prior to the detection date, so they fish are larger than when tagged. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, *O. mykiss* detected by the Guadalupe Creek antenna showing migratory tendencies were all most likely at the end of their first year.

3.3 Guadalupe River Results and Discussion

No *O. mykiss* were tagged within the Guadalupe River. A total of 125 *O. mykiss* were tagged in the upper watershed upstream of this station. The antenna is located in lower reaches of the Guadalupe River which is a migratory corridor, where limiting rearing occurs and spawning is unlikely. Due to these conditions, movement of *O. mykiss* can be assumed to be out-migrations. A single *O. mykiss* was detected at this station (Table 6). This fish was tagged in Alamitos Creek (Figure 13).

Table 6: *O. mykiss* tag number and associated information of fish detected at the Alamitos Creek antenna.

Date Tagged	Tag ID	Creek	Tagging Station	Length (FL)
10/22/2018	900.226000319368	Alamitos Creek	AC001	117

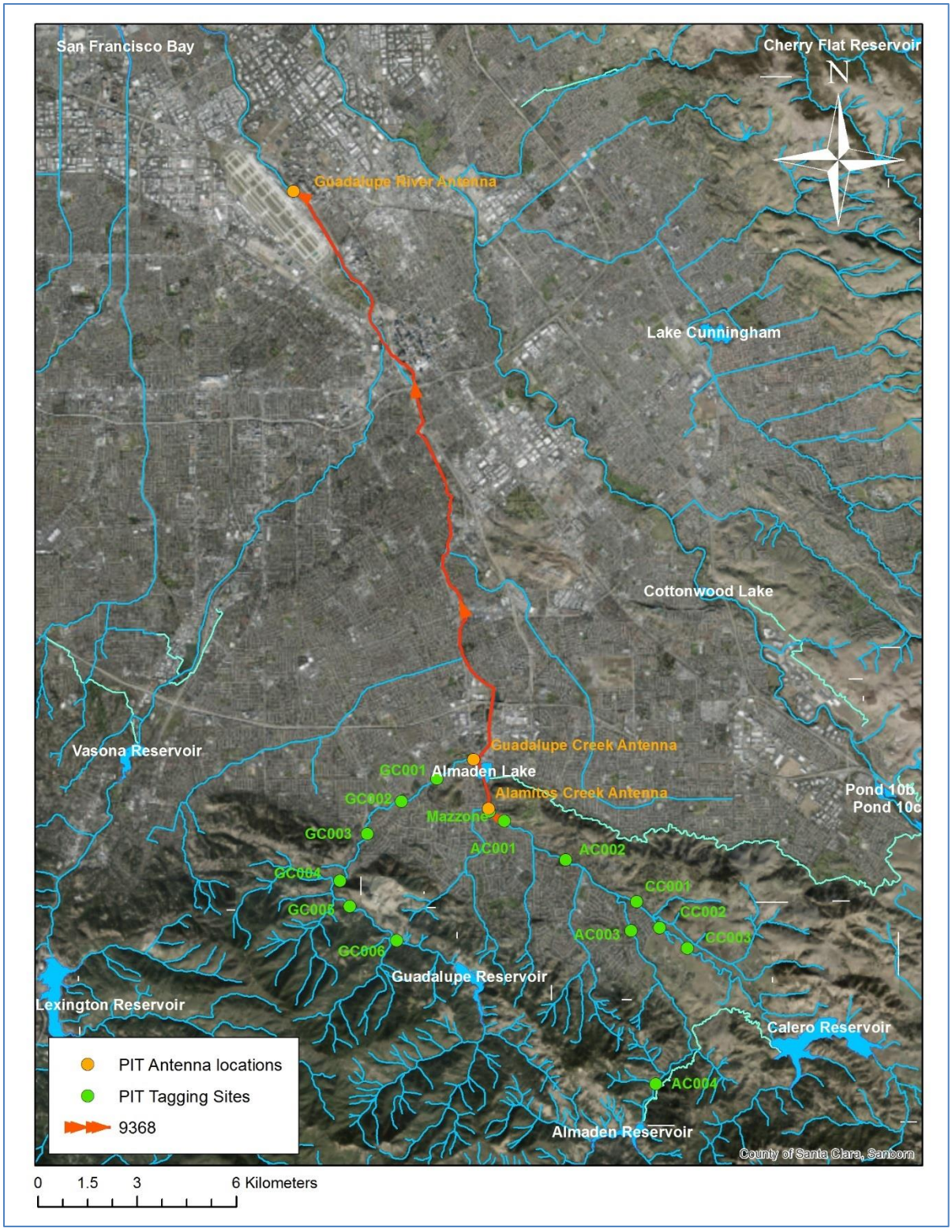


Figure 13: *O. mykiss* tagging locations in Alamitos, Calero, and Guadalupe Creeks and relative path to the Guadalupe River antenna.

A period of high flow occurred in the Guadalupe River between February and March. These high flows reduced the effectiveness of the antenna to detect out-migrating *O. mykiss* as only a small portion of the active channel width and water column was sampled by the antenna. The detection that did occur was on April 6, 2019 (Figure 14). This fish was tagged in Alamitos Creek, but was not detected by any of the other antennas in the watershed. This fish could have out-migrated from Alamitos Creek prior to the installation of the Alamitos Creek Antenna or it may not have been detected by the system. The number of fish detected by the Guadalupe River antenna does not provide an accurate depiction of the fish out-migrating through the Guadalupe River Watershed. It is expected other fish moved past the antenna but were not within the detection range. The detection does indicate outmigration is occurring in April and that the fish successfully navigated the Almaden Lake instream impoundment.

The *O. mykiss* detected by the Guadalupe River antenna had a 117 mm fork-length at the time of tagging, six months prior. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, this fish was likely at the end of its second year.

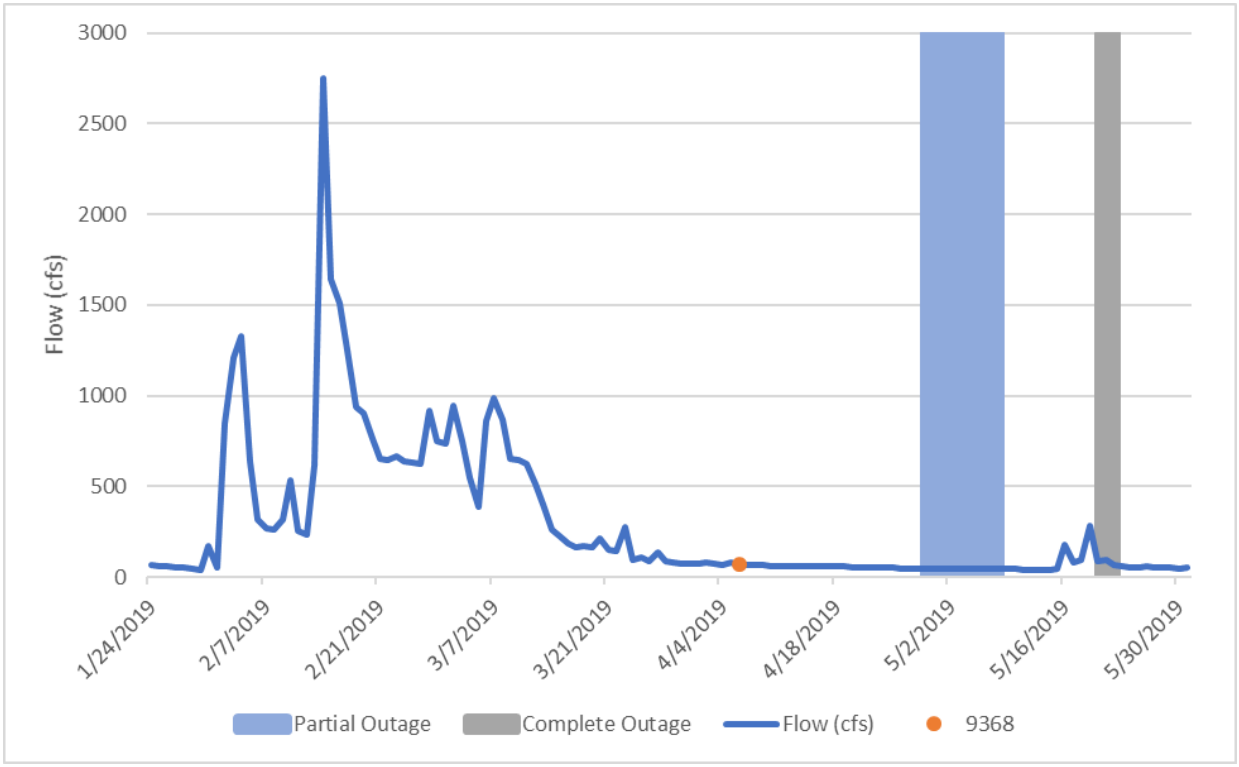


Figure 14: *O. mykiss* tracked on Guadalupe River comparted to flow on Guadalupe River at Highway 101 (USGS 11169025) Stream Gage and antenna outages. Numbers in legend indicate last four digits of O. mykiss PIT tag number.

4.0 CONCLUSION

This migration monitoring using PIT technology first and foremost indicated that tracking *O. mykiss* using this technology is feasible in the Guadalupe River Watershed. Fish were detected at all antennas, and lessons were learned about antenna placement, setup, and anchoring. This is a viable method in the Watershed and can provide valuable data about fish movement in the future.

O. mykiss showing migratory tendencies were recorded January through April, with the potential of fish moving as early as November and December from the Alamitos Creek system. Both Guadalupe Creek and Alamitos Creek contribute to outmigration, but no fish were detected from Calero Creek. Calero Creek had the least number of tagged fish (n=17), which could be contributing to the lack of detections. The antenna arrays indicate that inter-subwatershed movement is occurring. It also appears that *O. mykiss* might be entering the Guadalupe River Watershed from completely different watersheds. Based on the size of *O. mykiss* detected it is estimated that the *O. mykiss* showing migratory tendencies were at the end of their first and second year. The antenna also picked up non-migratory resident *O. mykiss* behavior which provided insight into use of restored habitat. With additional PIT tagging in the system a more robust dataset will develop over time.

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Santa Clara Valley Water District (VALLEY WATER). 2019. 2018 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed.

Smith and Leicester (2016) Guadalupe Creek Fish Sampling in October 2015 and 2016. California Department of Fish and Wildlife and San Jose State University.

Valley Water. 2020. Guadalupe River 2018-2019 Adult Salmonid Migration Monitoring Using the Vaki Riverwatcher Passive Monitoring System at The Alamitos Drop Structure.

Appendix A

Date	Creek	Species	Weight (g)	Length (mm)	PIT ID (Decimal)
12/16/2013	Guadalupe River	O. mykiss	-	134	982.000361656209
12/16/2013	Guadalupe River	O. mykiss	-	136	982.000361656215
12/16/2013	Guadalupe River	O. mykiss	-	155	982.000361656218
12/16/2013	Guadalupe River	O. mykiss	-	142	982.000361656222
12/16/2013	Guadalupe River	O. mykiss	-	-	982.000361656226
12/16/2013	Guadalupe River	O. mykiss	-	129	982.000361656230
12/16/2013	Guadalupe River	O. mykiss	-	133	982.000361656235
12/16/2013	Guadalupe River	O. mykiss	-	163	982.000361656237
12/16/2013	Guadalupe River	O. mykiss	-	125	982.000361656243
12/16/2013	Guadalupe River	O. mykiss	-	172	982.000361656249
12/16/2013	Guadalupe River	O. mykiss	-	151	982.000361656258
12/16/2013	Guadalupe River	O. mykiss	-	110	982.000362992258
12/16/2013	Guadalupe River	O. mykiss	-	160	982.000361656260
12/16/2013	Guadalupe River	O. mykiss	-	129	982.000361656263
12/16/2013	Guadalupe River	O. mykiss	-	230	982.000361656267
12/16/2013	Guadalupe River	O. mykiss	-	118	982.000362992269
12/16/2013	Guadalupe River	O. mykiss	-	175	982.000361656269
12/16/2013	Guadalupe River	O. mykiss	-	144	982.000361656274
12/16/2013	Guadalupe River	O. mykiss	-	122	982.000361656277
12/16/2013	Guadalupe River	O. mykiss	-	142	982.000361656278
12/16/2013	Guadalupe River	O. mykiss	-	112	982.000362992279
12/16/2013	Guadalupe River	O. mykiss	-	149	982.000361656280
12/16/2013	Guadalupe River	O. mykiss	-	135	982.000361656294
12/16/2013	Guadalupe River	O. mykiss	-	106	982.000362992296
12/16/2013	Guadalupe River	O. mykiss	-	122	982.000362992356
1/17/2014	Guadalupe River	O. mykiss	-	135	982.000361656216
1/17/2014	Los Gatos Creek	O. mykiss	-	115	982.000361656217
1/17/2014	Los Gatos Creek	O. mykiss	-	164	982.000361656229
1/17/2014	Guadalupe River	O. mykiss	-	156	982.000361656238
1/17/2014	Guadalupe River	O. mykiss	-	133	982.000361656247
1/17/2014	Guadalupe River	O. mykiss	-	120	982.000361656250
1/17/2014	Guadalupe River	O. mykiss	-	115	982.000361656252
1/17/2014	Guadalupe Creek	O. mykiss	-	80	982.000362992263
1/17/2014	Guadalupe River	O. mykiss	-	190	982.000361656264
1/17/2014	Guadalupe River	O. mykiss	-	150	982.000361656265
1/17/2014	Guadalupe Creek	O. mykiss	-	104	982.000362992272
1/17/2014	Guadalupe Creek	O. mykiss	-	85	982.000362992278
1/17/2014	Los Gatos Creek	O. mykiss	-	142	982.000361656288
1/17/2014	Guadalupe Creek	O. mykiss	-	93	982.000362992289
1/17/2014	Guadalupe Creek	O. mykiss	-	79	982.000362992290
1/17/2014	Guadalupe River	O. mykiss	-	119	982.000361656290
1/17/2014	Los Gatos Creek	O. mykiss	-	126	982.000361656298
1/17/2014	Los Gatos Creek	O. mykiss	-	89	982.000362992298
1/17/2014	Los Gatos Creek	O. mykiss	-	138	982.000361656299
1/17/2014	Guadalupe Creek	O. mykiss	-	75	982.000362992302
1/17/2014	Guadalupe Creek	O. mykiss	-	110	982.000362992303

1/17/2014	Guadalupe Creek	O. mykiss	-	155	982.000361656305
1/17/2014	Guadalupe Creek	O. mykiss	-	91	982.000362992306
1/17/2014	Guadalupe Creek	O. mykiss	-	91	982.000362992312
1/17/2014	Guadalupe Creek	O. mykiss	-	92	982.000362992315
1/17/2014	Guadalupe Creek	O. mykiss	-	71	982.000362992325
1/17/2014	Guadalupe Creek	O. mykiss	-	102	982.000362992327
1/17/2014	Guadalupe Creek	O. mykiss	-	79	982.000362992328
1/17/2014	Guadalupe Creek	O. mykiss	-	80	982.000362992330
1/17/2014	Guadalupe Creek	O. mykiss	-	110	982.000362992333
1/17/2014	Guadalupe Creek	O. mykiss	-	69	982.000362992340
1/17/2014	Guadalupe River	O. mykiss	-	138	982.000361656521
2/12/2014	Guadalupe River	O. mykiss	-	148	982.000361656219
2/12/2014	Guadalupe River	O. mykiss	-	189	982.000361656225
2/12/2014	Guadalupe River	O. mykiss	-	149	982.000361656227
2/12/2014	Guadalupe River	O. mykiss	-	179	982.000361656231
2/12/2014	Guadalupe River	O. mykiss	-	147	982.000361656242
2/12/2014	Guadalupe River	O. mykiss	-	156	982.000361656244
2/12/2014	Guadalupe River	O. mykiss	-	132	982.000361656272
2/12/2014	Guadalupe River	O. mykiss	-	193	982.000361656291
2/21/2014	Los Gatos Creek	O. mykiss	-	116	982.000361656213
2/21/2014	Los Gatos Creek	O. mykiss	-	142	982.000361656270
2/21/2014	Guadalupe River	O. mykiss	-	145	982.000361656311
2/21/2014	Los Gatos Creek	O. mykiss	-	112	982.000361656454
3/14/2014	Guadalupe River	O. mykiss	-	153	982.000361654515
3/15/2014	Pond A8	striped bass		520	982.000362654458
3/15/2014	Pond A8	striped bass		500	982.000362654476
3/15/2014	Pond A8	striped bass		530	982.000362655000
3/15/2014	Pond A8	striped bass		500	982.000362654505
3/15/2014	Pond A8	striped bass		440	982.000362654514
3/15/2014	Pond A8	striped bass		470	982.000362654539
4/17/2014	Pond A5	Leopard Shark	-	1219	982.000362654450
4/17/2014	Pond A5	Leopard Shark	-	838	982.000362654453
4/17/2014	Pond A5	Leopard Shark	-	864	982.000362654461
4/17/2014	Pond A5	Leopard Shark	-	914	982.000362654494
4/17/2014	Pond A5	Leopard Shark	-	864	982.000362654521
4/17/2014	Pond A5	Leopard Shark	-	889	982.000362654528
4/17/2014	Pond A8	striped bass		737	982.000362654448
4/17/2014	Pond A8	striped bass		762	982.000362654460
4/17/2014	Pond A8	striped bass		660	982.000362654466
4/17/2014	Pond A8	striped bass		787	982.000362654467
4/17/2014	Pond A8	striped bass		330	982.000362655150
4/17/2014	Pond A8	striped bass		762	982.000362654524
4/17/2014	Pond A8	striped bass		965	982.000362654529
4/17/2014	Pond A8	striped bass		305	982.000362654534
4/17/2014	Pond A8	striped bass		305	982.000362654537
4/17/2014	Pond A8	striped bass		838	982.000362654540
4/17/2014	Pond A8	striped bass		508	982.000362654543

10/19/2014	Alamitos Creek	O. mykiss		105	982.000362992262
10/19/2014	Alamitos Creek	O. mykiss		98	982.0003629923
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992288
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992271
10/19/2014	Guadalupe Creek	O. mykiss		65	982.000362992351
10/19/2014	Guadalupe Creek	O. mykiss		110	982.000362992281
10/19/2014	Guadalupe Creek	O. mykiss		90	982.000362992331
10/19/2014	Guadalupe Creek	O. mykiss		81	982.000362992285
11/2/2014	Guadalupe Creek	O. mykiss		146	982.000362655573
11/2/2014	Guadalupe Creek	O. mykiss		100	982.000362992305
11/2/2014	Guadalupe Creek	O. mykiss		117	982.000362992280
11/2/2014	Guadalupe Creek	O. mykiss		173	982.000362654463
11/2/2014	Guadalupe Creek	O. mykiss		124	982.000362654546
11/2/2014	Guadalupe Creek	O. mykiss		86	982.000362992307
11/2/2014	Guadalupe Creek	O. mykiss		67	982.000362992342
11/2/2014	Guadalupe Creek	O. mykiss		96	982.000362654480
11/3/2014	Guadalupe Creek	O. mykiss		NA	982.000360826977
11/3/2014	Guadalupe Creek	O. mykiss		93	982.000362992308
11/3/2014	Guadalupe Creek	O. mykiss		85	982.000360826958
11/3/2014	Guadalupe Creek	O. mykiss		72	982.000362992287
11/3/2014	Guadalupe Creek	O. mykiss		123	982.000362655643
11/3/2014	Guadalupe Creek	O. mykiss		120	982.000362655612
11/3/2014	Guadalupe Creek	O. mykiss		78	982.000362992353
11/3/2014	Guadalupe Creek	O. mykiss		139	982.000362655554
11/3/2014	Guadalupe Creek	O. mykiss		168	982.000362655626
11/3/2014	Guadalupe Creek	O. mykiss		72	982.000362992295
11/3/2014	Guadalupe Creek	O. mykiss		65	982.000362992317
11/3/2014	Guadalupe Creek	O. mykiss		88	982.000362992310
9/17/2018	Alamitos Creek	O. mykiss	43.06	146	900.226000319370
9/17/2018	Alamitos Creek	O. mykiss	15.14	111	900.226000319353
9/17/2018	Alamitos Creek	O. mykiss	-	199	900.226000319320
9/17/2018	Alamitos Creek	O. mykiss	17.20	109	900.226000319322
9/17/2018	Alamitos Creek	O. mykiss	13.30	102	900.226000319339
9/17/2018	Alamitos Creek	O. mykiss	15.09	107	900.226000319313
9/17/2018	Alamitos Creek	O. mykiss	8.33	89	900.226000319367
9/17/2018	Alamitos Creek	O. mykiss	-	248	900.226000319355
9/17/2018	Alamitos Creek	O. mykiss	12.92	103	900.226000319350
9/17/2018	Alamitos Creek	O. mykiss	21.42	119	900.226000319366
9/17/2018	Alamitos Creek	O. mykiss	19.34	117	900.226000319375
9/17/2018	Alamitos Creek	O. mykiss	16.51	111	900.226000319326
9/17/2018	Alamitos Creek	O. mykiss	23.78	122	900.226000319387
9/17/2018	Alamitos Creek	O. mykiss	26.74	132	900.226000319376
9/17/2018	Alamitos Creek	O. mykiss	30.42	141	900.226000319319
9/17/2018	Alamitos Creek	O. mykiss	32.10	136	900.226000319352
9/17/2018	Alamitos Creek	O. mykiss	13.30	103	900.226000319314
9/17/2018	Alamitos Creek	O. mykiss	32.70	138	900.226000319391
9/17/2018	Alamitos Creek	O. mykiss	25.26	129	900.226000319310

9/17/2018	Alamitos Creek	O. mykiss	11.50	97	900.226000319372
9/17/2018	Alamitos Creek	O. mykiss	81.27	186	900.226000319301
9/17/2018	Alamitos Creek	O. mykiss	19.01	117	900.226000319384
9/17/2018	Alamitos Creek	O. mykiss	14.39	104	900.226000319316
9/17/2018	Alamitos Creek	O. mykiss	11.97	102	900.226000319397
9/17/2018	Alamitos Creek	O. mykiss	10.00	95	900.226000319388
9/17/2018	Alamitos Creek	O. mykiss	14.48	106	900.226000319360
9/17/2018	Alamitos Creek	O. mykiss	18.58	115	900.226000319321
9/17/2018	Alamitos Creek	O. mykiss	23.03	122	900.226000319348
10/16/2018	Guadalupe Creek	O. mykiss	7.81	83	900.226000319227
10/16/2018	Guadalupe Creek	O. mykiss	9.25	87	900.226000319276
10/16/2018	Guadalupe Creek	O. mykiss	14.28	106	900.226000319293
10/16/2018	Guadalupe Creek	O. mykiss	4.75	67	900.226000319318
10/16/2018	Guadalupe Creek	O. mykiss	4.62	72	900.226000319305
10/16/2018	Guadalupe Creek	O. mykiss	3.72	66	900.226000319334
10/16/2018	Guadalupe Creek	O. mykiss	6.37	72	900.226000319341
10/16/2018	Guadalupe Creek	O. mykiss	3.58	65	900.226000319308
10/16/2018	Guadalupe Creek	O. mykiss	31.33	138	900.226000319389
10/16/2018	Guadalupe Creek	O. mykiss	6.82	81	900.226000319385
10/16/2018	Guadalupe Creek	O. mykiss	4.58	66	900.226000319338
10/16/2018	Guadalupe Creek	O. mykiss	5.32	74	900.226000319324
10/16/2018	Guadalupe Creek	O. mykiss	6.93	86	900.226000319364
10/16/2018	Guadalupe Creek	O. mykiss	6.66	79	900.226000319345
10/16/2018	Guadalupe Creek	O. mykiss	8.33	84	900.226000319358
10/16/2018	Guadalupe Creek	O. mykiss	6.12	76	900.226000319329
10/16/2018	Guadalupe Creek	O. mykiss	4.97	70	900.226000319351
10/17/2018	Guadalupe Creek	O. mykiss	5.62	75	900.226000319346
10/17/2018	Guadalupe Creek	O. mykiss	4.22	66	900.226000319394
10/17/2018	Guadalupe Creek	O. mykiss	6.02	79	900.226000319386
10/17/2018	Guadalupe Creek	O. mykiss	5.90	77	900.226000319340
10/17/2018	Guadalupe Creek	O. mykiss	4.52	70	900.226000319317
10/17/2018	Guadalupe Creek	O. mykiss	5.14	72	900.226000319337
10/17/2018	Guadalupe Creek	O. mykiss	8.05	86	900.226000319344
10/17/2018	Guadalupe Creek	O. mykiss	4.23	68	900.226000319330
10/17/2018	Guadalupe Creek	O. mykiss	6.06	75	900.226000319307
10/17/2018	Guadalupe Creek	O. mykiss	4.08	67	900.226000319309
10/17/2018	Guadalupe Creek	O. mykiss	3.83	65	900.226000319333
10/17/2018	Guadalupe Creek	O. mykiss	5.66	74	900.226000319361
10/17/2018	Guadalupe Creek	O. mykiss	96.04	199	900.228000613702
10/17/2018	Guadalupe Creek	O. mykiss	4.61	65	900.226000319381
10/17/2018	Guadalupe Creek	O. mykiss	6.62	76	900.226000319342
10/17/2018	Guadalupe Creek	O. mykiss	4.35	66	900.226000319399
10/17/2018	Guadalupe Creek	O. mykiss	4.63	70	900.226000319377
10/17/2018	Guadalupe Creek	O. mykiss	5.68	72	900.226000319371
10/17/2018	Guadalupe Creek	O. mykiss	6.23	75	900.226000319395
10/17/2018	Guadalupe Creek	O. mykiss	4.95	69	900.226000319325
10/17/2018	Guadalupe Creek	O. mykiss	6.20	78	900.226000319356

10/17/2018	Guadalupe Creek	O. mykiss	6.22	79	900.226000319374
10/17/2018	Guadalupe Creek	O. mykiss	4.36	69	900.226000319379
10/17/2018	Guadalupe Creek	O. mykiss	4.53	67	900.226000319354
10/17/2018	Guadalupe Creek	O. mykiss	18.15	112	900.226000319328
10/17/2018	Guadalupe Creek	O. mykiss	3.85	68	900.226000319393
10/17/2018	Guadalupe Creek	O. mykiss	5.05	79	900.226000319327
10/17/2018	Guadalupe Creek	O. mykiss	5.23	74	900.226000319362
10/17/2018	Guadalupe Creek	O. mykiss	11.22	90	900.226000319304
10/17/2018	Guadalupe Creek	O. mykiss	5.31	74	900.226000319398
10/18/2018	Alamitos Creek	O. mykiss	5.35	68	900.226000319284
10/18/2018	Alamitos Creek	O. mykiss	4.23	66	900.226000319260
10/18/2018	Alamitos Creek	O. mykiss	4.35	65	900.226000319291
10/18/2018	Alamitos Creek	O. mykiss	3.25	65	900.226000319292
10/18/2018	Alamitos Creek	O. mykiss	4.86	69	900.226000319295
10/18/2018	Alamitos Creek	O. mykiss	20.60	125	900.226000319250
10/18/2018	Alamitos Creek	O. mykiss	17.50	109	900.226000319246
10/18/2018	Alamitos Creek	O. mykiss	36.50	145	900.226000319258
10/18/2018	Alamitos Creek	O. mykiss	14.80	79	900.226000319263
10/18/2018	Alamitos Creek	O. mykiss	24.90	109	900.226000319201
10/18/2018	Alamitos Creek	O. mykiss	12.50	94	900.226000319218
10/18/2018	Alamitos Creek	O. mykiss	18.60	106	900.226000319269
10/18/2018	Alamitos Creek	O. mykiss	20.20	111	900.226000319200
10/18/2018	Alamitos Creek	O. mykiss	19.00	108	900.226000319311
10/18/2018	Alamitos Creek	O. mykiss	42.30	146	900.226000319257
10/18/2018	Alamitos Creek	O. mykiss	16.80	110	900.226000319290
10/22/2018	Alamitos Creek	O. mykiss	7.70	84	900.226000319343
10/22/2018	Alamitos Creek	O. mykiss	13.80	98	900.226000319306
10/22/2018	Alamitos Creek	O. mykiss	13.00	100	900.226000319349
10/22/2018	Alamitos Creek	O. mykiss	9.60	91	900.226000319312
10/22/2018	Alamitos Creek	O. mykiss	14.10	102	900.226000319315
10/22/2018	Alamitos Creek	O. mykiss	12.80	103	900.226000319382
10/22/2018	Alamitos Creek	O. mykiss	10.00	91	900.226000319365
10/22/2018	Alamitos Creek	O. mykiss	445.00	345	900.228000613703
10/22/2018	Alamitos Creek	O. mykiss	9.40	92	900.226000319363
10/22/2018	Alamitos Creek	O. mykiss	10.20	90	900.226000319390
10/22/2018	Alamitos Creek	O. mykiss	23.00	119	900.226000319378
10/22/2018	Alamitos Creek	O. mykiss	25.10	115	900.226000319396
10/22/2018	Alamitos Creek	O. mykiss	20.80	117	900.226000319368
10/22/2018	Alamitos Creek	O. mykiss	28.20	129	900.226000319380
10/23/2018	Calero Creek	O. mykiss	215.30	263	900.228000613704
10/23/2018	Calero Creek	O. mykiss	7.50	82	900.226000319280
10/23/2018	Calero Creek	O. mykiss	125.20	216	900.228000613705
10/23/2018	Calero Creek	O. mykiss	14.30	109	900.226000319268
10/23/2018	Calero Creek	O. mykiss	11.50	95	900.226000319336
10/23/2018	Calero Creek	O. mykiss	7.30	82	900.226000319302
10/23/2018	Calero Creek	O. mykiss	10.10	89	900.226000319332
10/23/2018	Calero Creek	O. mykiss	5.20	67	900.226000319373

10/24/2018	Calero Creek	O. mykiss	9.30	84	900.226000319357
10/24/2018	Calero Creek	O. mykiss	7.80	84	900.226000319347
10/24/2018	Calero Creek	O. mykiss	5.40	75	900.226000319323
10/24/2018	Calero Creek	O. mykiss	10.40	86	900.226000319300
10/24/2018	Calero Creek	O. mykiss	8.50	85	900.226000319231
10/24/2018	Calero Creek	O. mykiss	12.50	94	900.226000319244
10/24/2018	Calero Creek	O. mykiss	8.30	82	900.226000319287
10/24/2018	Calero Creek	O. mykiss	10.20	93	900.226000319230
10/24/2018	Calero Creek	O. mykiss	9.40	86	900.226000319212
11/6/2018	Guadalupe Creek	O. mykiss	12.40	95	900.226000319294
11/6/2018	Guadalupe Creek	O. mykiss	8.70	87	900.226000319214
11/6/2018	Guadalupe Creek	O. mykiss	18.20	116	900.226000319278
10/9/2019	Guadalupe Creek	O. mykiss	5.73	75	900.228000613710
10/9/2019	Guadalupe Creek	O. mykiss	6.60	84	900.226000319233
10/9/2019	Guadalupe Creek	O. mykiss	9.5	88	900.226000319239
10/9/2019	Guadalupe Creek	O. mykiss	7.1	81	900.226000319210
10/9/2019	Guadalupe Creek	O. mykiss	152.1	234	900.228000613711
10/9/2019	Guadalupe Creek	O. mykiss	5.1	71	900.226000319209
10/9/2019	Guadalupe Creek	O. mykiss	5.8	77	900.226000319277
10/9/2019	Guadalupe Creek	O. mykiss	9.6	85	900.226000319220
10/9/2019	Guadalupe Creek	O. mykiss	53.6	168	900.228000613712
10/9/2019	Guadalupe Creek	O. mykiss	14.7	104	900.226000319222
10/9/2019	Guadalupe Creek	O. mykiss	8.6	84	900.226000319228
10/9/2019	Guadalupe Creek	O. mykiss	8.0	76	900.226000319237
10/10/2019	Alamitos Creek	O. mykiss	11.4	95	900.226000319265
10/10/2019	Guadalupe Creek	O. mykiss	8.6	82	900.226000319288
10/10/2019	Guadalupe Creek	O. mykiss	8.6	86	900.226000319208
10/10/2019	Guadalupe Creek	O. mykiss	9.4	89	900.226000319252
10/10/2019	Guadalupe Creek	O. mykiss	3.4	66	900.226000319369
10/10/2019	Guadalupe Creek	O. mykiss	7.9	85	900.226000319249
10/10/2019	Guadalupe Creek	O. mykiss	41.7	150	900.226000319215
10/10/2019	Guadalupe Creek	O. mykiss	16.3	106	900.226000319204
10/10/2019	Guadalupe Creek	O. mykiss	6.5	82	900.226000319296
10/10/2019	Guadalupe Creek	O. mykiss	14.3	99	900.226000319261
10/10/2019	Guadalupe Creek	O. mykiss	7.1	81	900.226000319206
10/10/2019	Guadalupe Creek	O. mykiss	10.2	91	900.226000319242
10/10/2019	Guadalupe Creek	O. mykiss	7.7	81	900.226000319219
10/10/2019	Guadalupe Creek	O. mykiss	9.5	89	900.226000319216
10/10/2019	Guadalupe Creek	O. mykiss	10.4	91	900.226000319281
10/10/2019	Guadalupe Creek	O. mykiss	12.3	100	900.226000319217
10/10/2019	Guadalupe Creek	O. mykiss	16.5	107	900.226000319272
10/10/2019	Guadalupe Creek	O. mykiss	13.4	104	900.226000319247
10/23/2019	Alamitos Creek	O. mykiss	7.9	83	900.226000319254
10/23/2019	Alamitos Creek	O. mykiss	11.5	87	900.226000319203
10/23/2019	Alamitos Creek	O. mykiss	5.5	75	900.226000319205
10/23/2019	Alamitos Creek	O. mykiss	3.3	65	900.226000319225
10/23/2019	Alamitos Creek	O. mykiss	3.9	68	900.226000319282

10/23/2019	Alamitos Creek	O. mykiss	4.9	71	900.226000319224
10/23/2019	Alamitos Creek	O. mykiss	5.7	76	900.226000319248
10/23/2019	Alamitos Creek	O. mykiss	13.9	105	900.226000319221
10/23/2019	Alamitos Creek	O. mykiss	5.3	72	900.226000319226
10/23/2019	Alamitos Creek	O. mykiss	4.1	68	900.226000319202
10/23/2019	Alamitos Creek	O. mykiss	4.8	69	900.226000319223
10/23/2019	Alamitos Creek	O. mykiss	14.4	105	900.226000319236
10/23/2019	Alamitos Creek	O. mykiss	4.7	67	900.226000319240
10/23/2019	Alamitos Creek	O. mykiss	22.9	122	900.226000319274
10/23/2019	Alamitos Creek	O. mykiss	5.2	73	900.226000319283
10/23/2019	Alamitos Creek	O. mykiss	10.7	90	900.226000319273
10/23/2019	Alamitos Creek	O. mykiss	15.1	106	900.226000319256
10/23/2019	Alamitos Creek	O. mykiss	9.0	88	900.226000319211
10/28/2019	Calero Creek	O. mykiss	250.1	280	900.228000613713
10/28/2019	Calero Creek	O. mykiss	7.9	85	900.226000319259
10/28/2019	Calero Creek	O. mykiss	6.6	81	900.226000319297
10/28/2019	Calero Creek	O. mykiss	12.4	96	900.226000319285
10/28/2019	Calero Creek	O. mykiss	14.6	107	900.226000319286
10/28/2019	Calero Creek	O. mykiss	12.3	95	900.226000319207
10/28/2019	Calero Creek	O. mykiss	8.5	86	900.226000319245
10/30/2019	Guadalupe River	O. mykiss	169.6	248	900.228000613714
10/31/2019	Alamitos Creek	O. mykiss	7.0	81	900.226000319270
10/31/2019	Alamitos Creek	O. mykiss	12.2	99	900.226000319232
10/31/2019	Alamitos Creek	O. mykiss	28.8	134	900.226000319213
10/31/2019	Alamitos Creek	O. mykiss	11.7	95	900.226000319241
10/31/2019	Alamitos Creek	O. mykiss	5.8	75	900.226000319267
10/31/2019	Alamitos Creek	O. mykiss	10.7	90	900.226000319298
10/31/2019	Alamitos Creek	O. mykiss	6.3	76	900.226000319299
10/31/2019	Alamitos Creek	O. mykiss	13.4	98	900.226000319234
10/31/2019	Alamitos Creek	O. mykiss	11.6	93	900.226000319271
10/31/2019	Alamitos Creek	O. mykiss	11.5	95	900.226000319238
10/31/2019	Alamitos Creek	O. mykiss	11.9	99	900.226000319255
10/31/2019	Alamitos Creek	O. mykiss	8.5	90	900.226000319251
10/31/2019	Alamitos Creek	O. mykiss	15.9	103	900.226000319262
10/31/2019	Alamitos Creek	O. mykiss	25.4	130	900.226000319253
10/31/2019	Alamitos Creek	O. mykiss	12.0	96	900.226000319229
10/31/2019	Alamitos Creek	O. mykiss	14.1	97	900.226000319275
10/31/2019	Alamitos Creek	O. mykiss	20.2	115	900.226000319279
10/31/2019	Alamitos Creek	O. mykiss	33.6	140	982.126058146080
10/31/2019	Alamitos Creek	O. mykiss	18.9	112	982.126058146069
10/31/2019	Alamitos Creek	O. mykiss	19.5	117	982.126058146081
10/31/2019	Alamitos Creek	O. mykiss	15.1	105	982.126058146089
10/31/2019	Alamitos Creek	O. mykiss	6.6	80	982.126058146053
10/31/2019	Alamitos Creek	O. mykiss	65.4	173	900.228000613716
10/31/2019	Alamitos Creek	O. mykiss	281.8	280	900.228000613715
10/31/2019	Alamitos Creek	O. mykiss	60.3	170	900.228000613718
10/31/2019	Alamitos Creek	O. mykiss	40.1	150	900.228000613717

11/4/2019	Upper Penitencia	O. mykiss	5.2	74	982.126058146054
11/4/2019	Upper Penitencia	O. mykiss	6.0	76	982.126058146126
11/4/2019	Upper Penitencia	O. mykiss	7.0	79	982.126058146101
11/4/2019	Upper Penitencia	O. mykiss	9.3	89	982.126058146077
11/4/2019	Upper Penitencia	O. mykiss	75.1	189	900.228000613719
11/4/2019	Upper Penitencia	O. mykiss	17.8	111	982.126058146117
11/4/2019	Upper Penitencia	O. mykiss	15.1	108	982.126058146065
11/4/2019	Upper Penitencia	O. mykiss	9.9	94	982.126058146106
11/4/2019	Upper Penitencia	O. mykiss	9.1	88	982.126058146036
11/4/2019	Upper Penitencia	O. mykiss	96.5	209	900.228000613720
11/4/2019	Upper Penitencia	O. mykiss	151.3	236	900.228000613721
11/4/2019	Upper Penitencia	O. mykiss	-	-	900.228000613722
11/4/2019	Upper Penitencia	O. mykiss	12.4	97	982.126058146093
11/4/2019	Upper Penitencia	O. mykiss	7.8	85	982.126058146039
11/4/2019	Upper Penitencia	O. mykiss	11.3	93	982.126058146070
11/4/2019	Upper Penitencia	O. mykiss	63.9	177	900.228000613723
11/4/2019	Upper Penitencia	O. mykiss	5.1	74	982.126058146083
11/4/2019	Upper Penitencia	O. mykiss	59.4	178	900.228000613724
11/4/2019	Upper Penitencia	O. mykiss	13.8	105	982.126058146067
11/4/2019	Upper Penitencia	O. mykiss	8.5	84	982.126058146084
11/4/2019	Upper Penitencia	O. mykiss	-	79	982.126058146042
11/4/2019	Upper Penitencia	O. mykiss	24.1	130	982.126058146043
11/4/2019	Upper Penitencia	O. mykiss	-	106	982.126058146105
11/4/2019	Upper Penitencia	O. mykiss	12	92	982.126058146111
11/4/2019	Upper Penitencia	O. mykiss	4.5	73	982.126058146044
11/4/2019	Upper Penitencia	O. mykiss	7.6	84	982.126058146100
11/4/2019	Upper Penitencia	O. mykiss	17.3	108	982.126058146116
11/4/2019	Upper Penitencia	O. mykiss	48.2	162	900.228000613726
11/4/2019	Upper Penitencia	O. mykiss	10.8	92	982.126058146058
11/4/2019	Upper Penitencia	O. mykiss	41.1	158	900.228000613727
11/4/2019	Upper Penitencia	O. mykiss	8.7	91	982.126058146085
11/4/2019	Upper Penitencia	O. mykiss	5.2	73	982.126058146095
11/4/2019	Upper Penitencia	O. mykiss	7.2	85	982.126058146103
11/4/2019	Upper Penitencia	O. mykiss	15.5	103	982.126058146046
11/4/2019	Upper Penitencia	O. mykiss	10.7	100	982.126058146074
11/4/2019	Upper Penitencia	O. mykiss	5.8	78	982.126058146076
11/4/2019	Upper Penitencia	O. mykiss	41.9	156	900.228000613728
11/4/2019	Upper Penitencia	O. mykiss	38.6	145	982.126058146034
11/4/2019	Upper Penitencia	O. mykiss	49.2	162	900.228000613730
11/4/2019	Upper Penitencia	O. mykiss	12.5	101	982.126058146096
11/4/2019	Upper Penitencia	O. mykiss	6.2	78	982.126058146055
11/4/2019	Upper Penitencia	O. mykiss	13.3	96	982.126058146033
11/4/2019	Upper Penitencia	O. mykiss	8.7	88	982.126058146037
11/4/2019	Upper Penitencia	O. mykiss	6.9	83	982.126058146063
11/4/2019	Upper Penitencia	O. mykiss	13.1	102	982.126058146071
11/4/2019	Upper Penitencia	O. mykiss	143.1	234	900.228000613729
11/4/2019	Upper Penitencia	O. mykiss	5.8	75	982.126058146129

11/4/2019	Upper Penitencia	O. mykiss	19.7	112	982.126058146064
11/4/2019	Upper Penitencia	O. mykiss	55.3	172	900.228000613731
11/4/2019	Upper Penitencia	O. mykiss	11.5	98	982.126058146079
11/4/2019	Upper Penitencia	O. mykiss	19.2	112	982.126058146068
11/4/2019	Upper Penitencia	O. mykiss	6.2	79	982.126058146092
11/4/2019	Upper Penitencia	O. mykiss	7.9	86	982.126058146056
11/4/2019	Upper Penitencia	O. mykiss	5.3	77	982.126058146087
11/4/2019	Upper Penitencia	O. mykiss	6.3	81	982.126058146048
11/4/2019	Upper Penitencia	O. mykiss	8.7	90	982.126058146062
11/4/2019	Upper Penitencia	O. mykiss	6.3	78	982.126058146041
11/4/2019	Upper Penitencia	O. mykiss	13.9	101	982.126058146098
11/4/2019	Upper Penitencia	O. mykiss	5.5	77	982.126058146113
11/4/2019	Upper Penitencia	O. mykiss	5.1	74	982.126058146115
11/4/2019	Upper Penitencia	O. mykiss	8.6	90	982.126058146088
11/4/2019	Upper Penitencia	O. mykiss	171.5	245	900.228000613732
11/6/2019	Coyote Creek	O. mykiss	18.1	112	982.126058146078
11/6/2019	Coyote Creek	O. mykiss	23.2	122	982.126058146114
11/6/2019	Coyote Creek	O. mykiss	28.2	133	982.126058146107
11/13/2019	Upper Penitencia	O. mykiss	31.8	141	982.126058146110
11/13/2019	Upper Penitencia	O. mykiss	10.6	95	982.126058146131
11/13/2019	Upper Penitencia	O. mykiss	38.8	153	900.228000613734
11/13/2019	Upper Penitencia	O. mykiss	24.8	128	982.126058146118
11/13/2019	Upper Penitencia	O. mykiss	20.4	125	982.126058146082
11/13/2019	Upper Penitencia	O. mykiss	58.2	172	900.228000613735
11/13/2019	Upper Penitencia	O. mykiss	54.7	168	900.228000613736
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11/13/2019	Upper Penitencia	O. mykiss	46.3	159	900.228000613739
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11/13/2019	Upper Penitencia	O. mykiss	96.5	204	900.228000613737
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11/13/2019	Upper Penitencia	O. mykiss	119.5	224	900.228000613742
11/13/2019	Upper Penitencia	O. mykiss	7.5	84	982.126058146051
11/13/2019	Upper Penitencia	O. mykiss	7.5	86	982.126058146038
11/13/2019	Upper Penitencia	O. mykiss	30.5	140	982.126058146123
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11/13/2019	Upper Penitencia	O. mykiss	12.2	97	982.126058146032
11/13/2019	Upper Penitencia	O. mykiss	8.7	80	982.126058146073
11/13/2019	Upper Penitencia	O. mykiss	23.6	125	982.126058146047
11/13/2019	Upper Penitencia	O. mykiss	15.7	94	982.126058146122
11/13/2019	Upper Penitencia	O. mykiss	13.8	94	982.126058146049
11/13/2019	Upper Penitencia	O. mykiss	9.1	86	982.126058146109
11/13/2019	Upper Penitencia	O. mykiss	8.8	84	982.126058146052
11/13/2019	Upper Penitencia	O. mykiss	24.5	124	982.126058146099
11/13/2019	Upper Penitencia	O. mykiss	26.3	128	982.126058146128
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11/13/2019	Upper Penitencia	O. mykiss	38.5	134	982.126058146124

11/13/2019	Upper Penitencia	O. mykiss	2.9	84	982.126058146045
11/13/2019	Upper Penitencia	O. mykiss	110.3	209	900.228000613744
11/13/2019	Upper Penitencia	O. mykiss	28.9	132	982.126058146108
11/13/2019	Upper Penitencia	O. mykiss	12.4	96	982.126058146090
11/13/2019	Upper Penitencia	O. mykiss	37.2	154	982.126058146059

GUADALUPE RIVER 2018-2019 ADULT SALMONID MIGRATION MONITORING USING THE VAKI RIVERWATCHER PASSIVE MONITORING SYSTEM AT THE ALAMITOS DROP STRUCTURE



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January 30, 2020

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INTRODUCTION

Steelhead (*Oncorhynchus mykiss*) in the Central California Coast (CCC) Distinct Population Segment were listed as threatened by the National Marine Fisheries Service (NMFS) in 1997. Due to their protected status, the Santa Clara Valley Water District (Valley Water) decided to implement a noninvasive means of documenting steelhead escapement and passage through the Alamitos fishway on the Guadalupe River. The equipment chosen to accomplish the task was the Vaki Riverwatcher (Vaki), a computer-based fish counter which employs scanner plates and a digital camera to capture videos and silhouette images of fish as they pass between the plates. This monitoring also detects other anadromous fish such as Chinook salmon (*Oncorhynchus tshawytscha*), and Pacific lamprey (*Entosphenus tridentatus*). The monitoring season selected allows for these species to be detected. The Vaki provides information on the occurrence and timing of adult fish migration as they pass both upstream and downstream through the counter.

The Alamitos fish ladder is located 32 kilometers upstream of the South San Francisco Bay on the Guadalupe River between Coleman Road and Blossom Hill Road, just downstream of Almaden Lake in San Jose, California (Figure 1). The fish ladder was installed in November 1999 at the Alamitos Drop Structure, a 4 meter tall structure that had previously created an impassable barrier to fish migration. The installation of the Alamitos Fishway opened up an additional 27 kilometers of upstream habitat for migrating fish. The Vaki was first deployed in the most downstream weir of the Alamitos Fishway for three monitoring seasons (from 2003 to 2006). This was to assess the function of the Alamitos Fishway. During this monitoring, it was determined that the ladder functions as intended, and *O. mykiss* and Chinook salmon can navigate the ladder. During the 2018 migration season, the Vaki was reinstalled at the Alamitos fish ladder (SCVWD 2019). This monitoring resumed for the 2019 monitoring season which is the focus of this report. The Vaki provided documentation of anadromous fish passage through the Guadalupe River as well as the Alamitos Fishway. It also serves as a potential tool for estimating adult escapement into the upper Guadalupe Watershed.

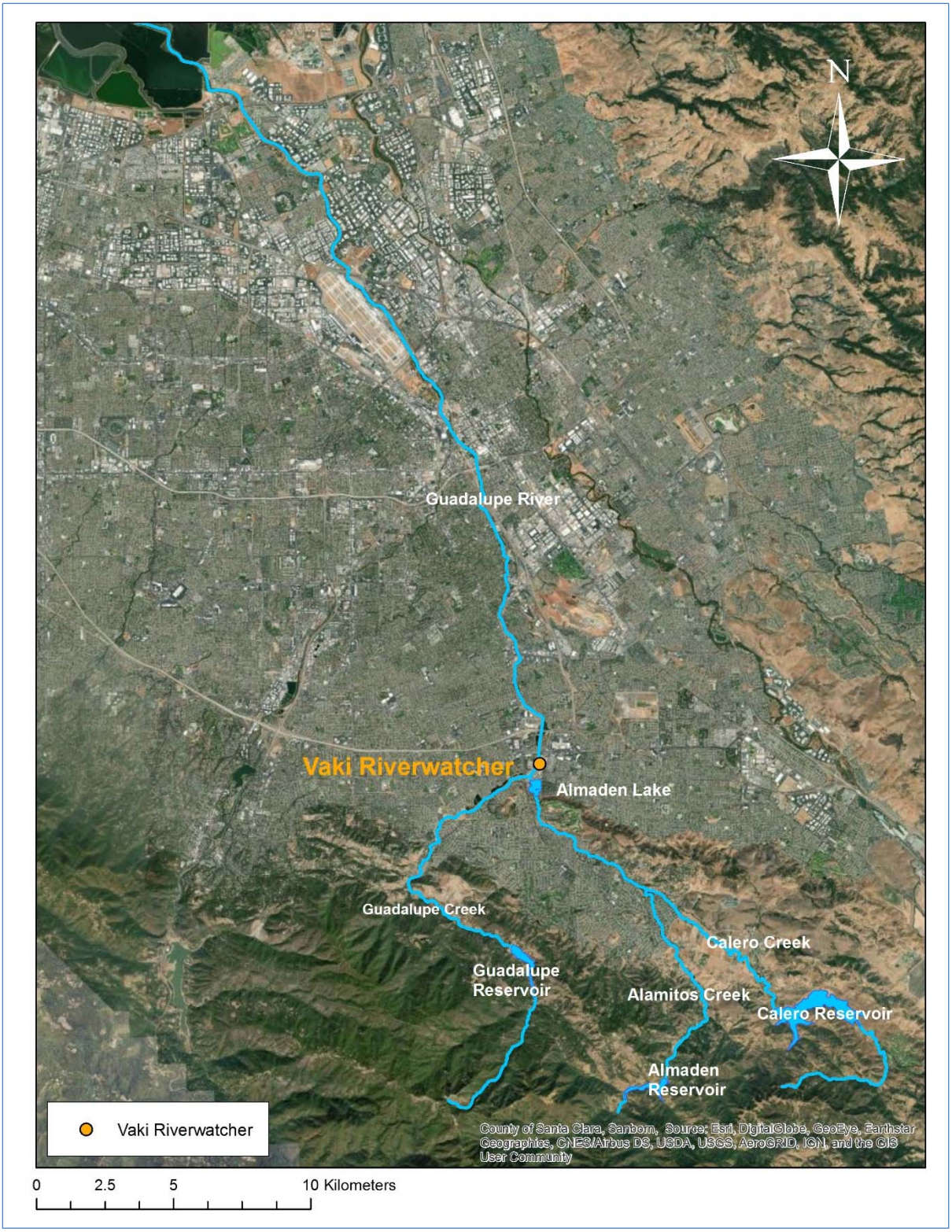


Figure 1: Location of Vaki Riverwatcher in the Guadalupe River Watershed.

OPERATION, INSTALLATION, AND MAINTENANCE

The Vaki was installed on October 17, 2018 and removed on May 23, 2019. The counter itself is a rectangular-shaped unit outfitted with infrared light emitting diodes on the interior and is completely submerged underwater within the fish ladder (Figure 2). Adult fish are directed through the counter opening by use of weirs in the ladder. When a fish swims through the counter and breaks the plane of light beams, the fish is scanned and a resulting silhouette image is sent to the onsite computer. Other information recorded as the fish passes through the counter includes the speed the fish was traveling, the direction the fish was moving (upstream or downstream), the body depth of the passing fish (for estimating length based on length-to-depth ratios), along with the date and time. A fish detection at the scanner plates then triggers an underwater digital camera which records a 4.1 second video for fish traveling upstream or a 14.4 second video for fish traveling downstream. This enables the user to scan through the videos to confirm the presence of a fish and improves confidence in species identification. All the data collected by the Vaki are stored by the attached onsite computer.



Figure 2: Vaki Riverwatcher system being installed in the Alamitos Fishway. The red box indicates the fish counter.

The Vaki was maintained and cleaned from installation until its removal on May 23, 2019, twice a week by removing debris and algal build up on the scanner plates and plexiglass in front of the camera with a Mr. Long Arm® brush. Data was manually downloaded from the onsite database, which was reset during each of these checks. The files were manually vetted as soon as possible.

The Vaki is powered by four 6-volt batteries that are charged by a solar panel. On a few occasions after several cloudy or rainy days, the battery reserve would drop so low that the Vaki would only record a silhouette image for each detection with no accompanying video. The Vaki also completely lost power due to this same issue during the time frames recorded in Table 1. Additionally, for approximately seven days in January the Vaki was not functioning properly as flow conditions created low light and high turbidity that exceeded the operational range of the unit causing it to be unable to trigger fish detections (Table 1). For three hours on March 28, 2019, the Vaki was removed from the fishway for maintenance (Table 1). These are all the periods that migrating fish could have been missed. These outages add up to a total of 16 days where fish were not being tracked.

Table 1: Vaki outage durations and causes.

Duration of outage	Cause of outage	Start of outage	End of outage
71 hours	Power outage	11/24/2018 3:22 am	11/27/2018 2:51 am
16 hours	Power outage	11/29/2018 10:12 pm	11/30/2018 2:00 pm
87 hours	Power outage	11/30/2018 8:11 pm	12/3/2018 10:52 am
37 hours	Power outage	12/3/2018 unknown time	12/4/2018 12:12 pm
170 hours	Environmental Conditions	1/16/2019 4:30 pm	1/23/2019 6:06 pm
3 hours	Maintenance	3/28/2019 7:50 am	3/28/2019 11:00 am
Total duration of outage: 384 hours (16 days)			

DATA ANALYSIS

The Vaki records silhouettes and videos of all items large enough to break the plane of the diodes. Scanned infrared silhouettes and video images were reviewed by Valley Water staff to ensure that only fish passage events were included in the overall passage counts. Video images were used to identify fish to species when conditions provided clear images. Silhouettes were also used to identify the fish to species if identifying characteristics were depicted. A confidence level rating system (Figure 2) analyzing both silhouette and video quality was used to rate the likelihood of accurate

identification for *O. mykiss*, Chinook salmon (*Oncorhynchus tshawytscha*), and Pacific lamprey (*Entosphenus tridentatus*). Detection events without accompanying videos were only sorted into specific species categories if the silhouette was particularly clear and the confidence level of identification was high; otherwise, these detections were sorted into the "unknown fish" category.

Table 2: Confidence rating system used for identifying fish detections to species for *O. mykiss*, *O. tshawytscha*, and *Entosphenus tridentatus*.

	High quality video	**Average quality video**	**Poor quality video**	**Video absent**
High quality silhouette	High confidence	High confidence	Medium confidence	Medium confidence
Average quality silhouette	High confidence	High confidence	Medium confidence	Low confidence
Poor quality silhouette	High confidence	Medium confidence	Low confidence	Can't be categorized
Silhouette absent	High confidence	Medium confidence	Low confidence	N/A

Length-to-depth ratios were used to estimate the lengths of specific individuals based upon their body depth as measured by the Vaki. The length-to-depth ratios for *O. mykiss* were 4.1:1 for fish length up to 400 mm fish and 4.8:1 for length 401 to 1000 mm (Cuthbert et al. 2012). The length-to-depth ratios for Chinook salmon was 4.1:1 for all sized fish (Cuthbert et al. 2012). No length-to-depth ratios were available for Pacific lamprey.

Steelhead with a standard length greater than 350 mm were classified as an adult steelhead, while anything 350 mm and below were determined to be juvenile *O. mykiss* (Moyle, 2002). The scanner plates trigger a detection and a video recording only when a body depth of 40 mm or greater is detected. This results in a lack of detection for *O. mykiss* with an estimated standard length of 159 mm or less.

Since one fish may move upstream and downstream through the fish counter multiple times in a given time span, body depths along with proximity in timing were used to differentiate detections of Chinook salmon at the individual level in order to obtain a more accurate count on total number of Chinook salmon passing through the counter. *O. mykiss* detections were not able to be analyzed to determine a specific number of individual fish because all *O. mykiss* detections were juvenile fish. Their small size allows these juvenile fish to swim between the weir bars thus avoiding detection by the Vaki and reducing the accuracy of determining the number of individual fish.

The Vaki system is designed to track adult migratory fish with a clear migratory path (i.e., anadromous fish). The system does not provide the ability to estimate the number of fish using the habitat that the system is installed in. For Centrarchidae, Cyprinidae, and Catostomidae species that are not migrating, detection indicates presence, but cannot develop population numbers. These species were lumped by family for data analysis purposes, but if positive identification was possible the species was noted.

RESULTS

During the 2018-2019 monitoring season, *O. mykiss*, Chinook salmon, Pacific lamprey, Sacramento sucker (*Catostomus occidentalis*), Centrarchids, and Cyprinids were documented passing through the Alamitos fish ladder Vaki. There was a total of 744 fish detections throughout the time the Vaki was installed with Centrarchids and Sacramento sucker being the most commonly identified species, with 233 and 123 detections, respectively (Figure 3). One Pacific lamprey was identified; however, confidence in the species identification was low. Unknown fish was the highest category of fish discerned by the Vaki system. This was a result of the high flows and turbid conditions from the precipitation events that occurred in WY 2019.

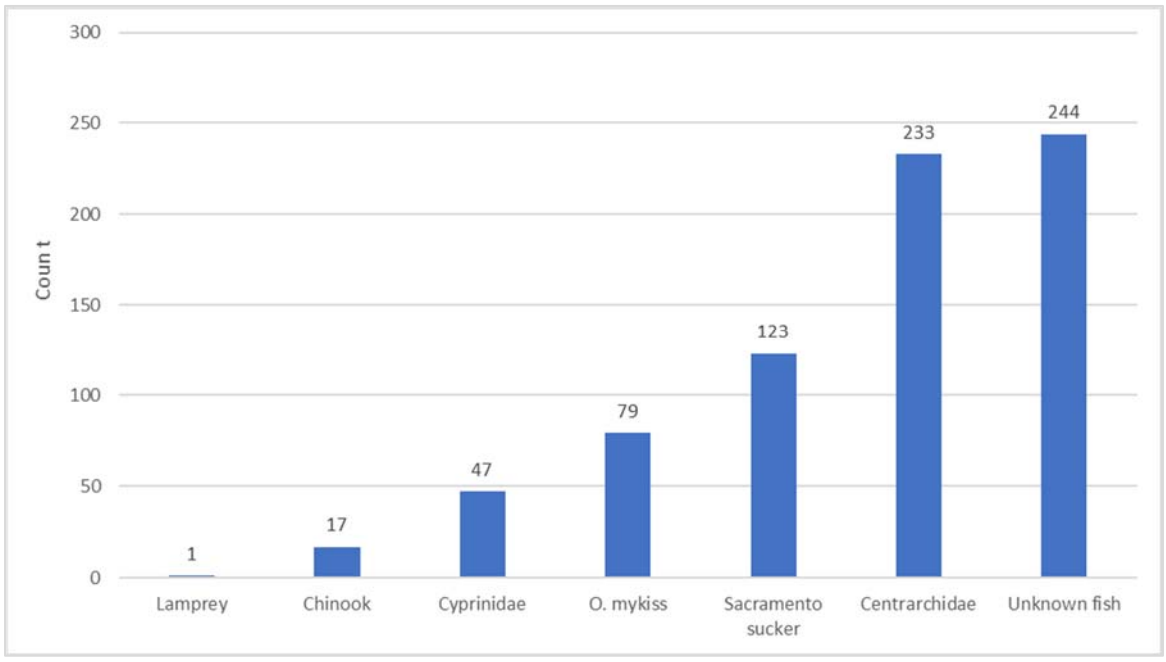


Figure 3: Number of detections of each fish species/family throughout the Guadalupe River Vaki deployment period (2018-2019 monitoring period).

The Centrarchidae species positively identified using the Vaki system included largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and black crappie (*Pomoxis nigromaculatus*). The Cyprinidae species positively identified by the

system included common carp (*Cyprinus carpio*). Examples of positive identifications can be seen in Appendix A.

Detections of O. mykiss, Chinook salmon, and Pacific lamprey were run through the confidence matrix. The confidence rating in those detections can be seen in Table 3.

Table 3: Confidence rating for anadromous fish detections based on Table 2.

Confidence Rating	High	Medium	Low	Total
O. mykiss	69	9	1	79
Chinook Salmon	4	12	1	17
Pacific Lamprey	0	0	1	1

Of the 79 *O. mykiss* detections, 42 were recorded moving upstream and 37 were moving downstream (Table 4). There were six instances where two *O. mykiss* were observed in the video accompanying a single detection, and one instance where three *O. mykiss* were observed in the video accompanying a single detection. This means there were eight additional *O. mykiss* passage events that were not counted by the Vaki. These detections do not indicate individual fish, but are rather instances that fish passed through the Vaki system. The estimated size of *O. mykiss* detected ranged from 160 mm to 270 mm. There were no Vaki detections of adult steelhead (size class >350 mm). The timing of *O. mykiss* detections can be seen in Figure 4.

Of the 17 Chinook salmon detections, 15 were recorded moving upstream and two were moving downstream (Table 4). The estimated lengths ranged from 370 mm to 580 mm. The timing of Chinook salmon detections can be seen in Figure 5.

A single Pacific lamprey was potentially detected moving upstream. The silhouette and video were both poor quality, providing low confidence in this detection. Length estimates were not calculated as no length-to-depth ratio was available for Pacific lamprey. The timing of Pacific lamprey detections can be seen in Figure 4.

Table 4: Upstream and downstream movement for anadromous fish.

Species	Upstream	Downstream
O. mykiss	42	37
Chinook Salmon	15	2
Pacific Lamprey	1	0

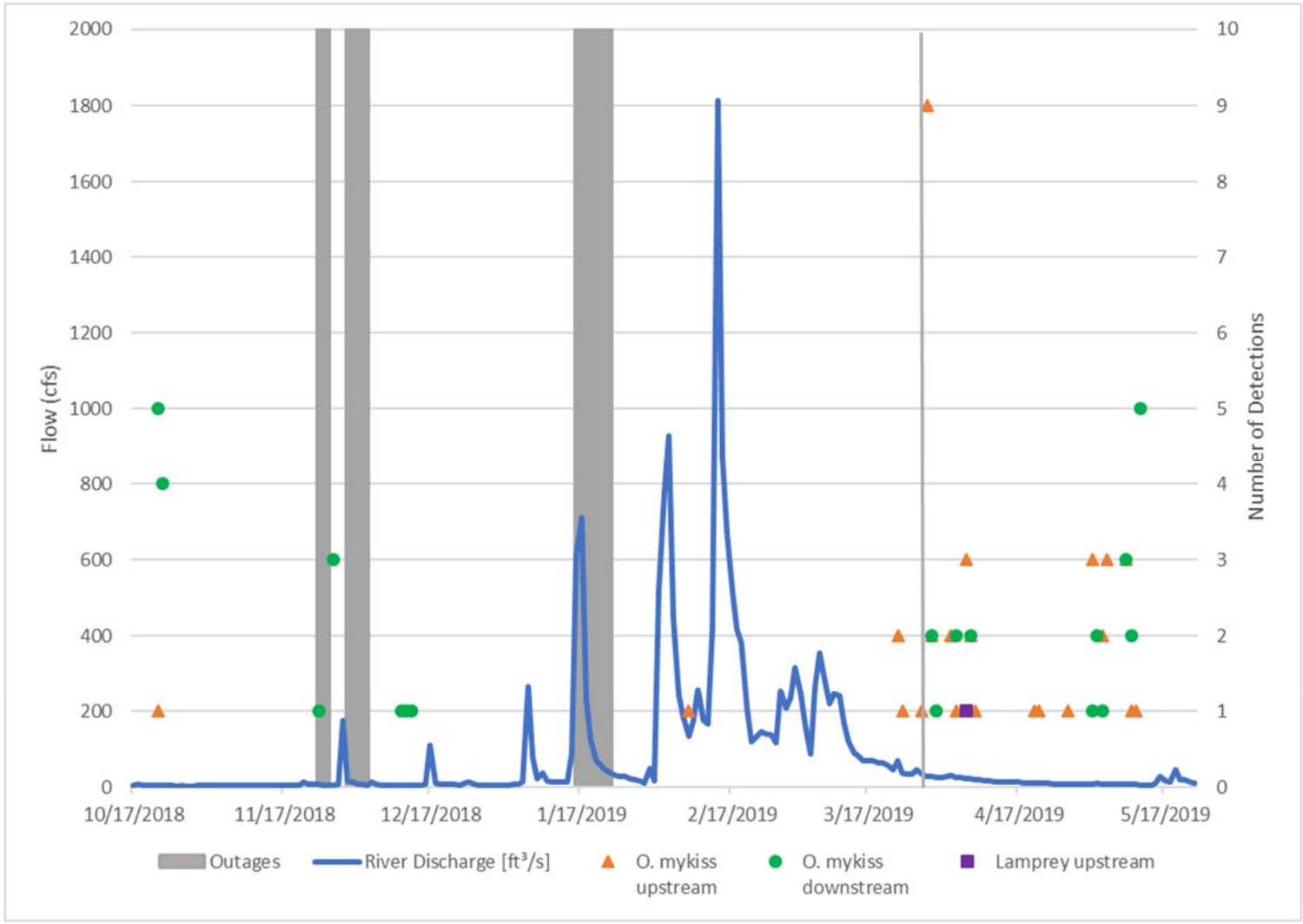


Figure 4: *O. mykiss* and Pacific lamprey detections per day (right y-axis) in relation to cubic feet per second (cfs) daily averages (left y-axis) on the Guadalupe River stream gage ALERT 5023b above Almaden Expwy. This is based on the number of Vaki detections and does not account for the seven occasions when multiple *O. mykiss* were observed in a single detection.

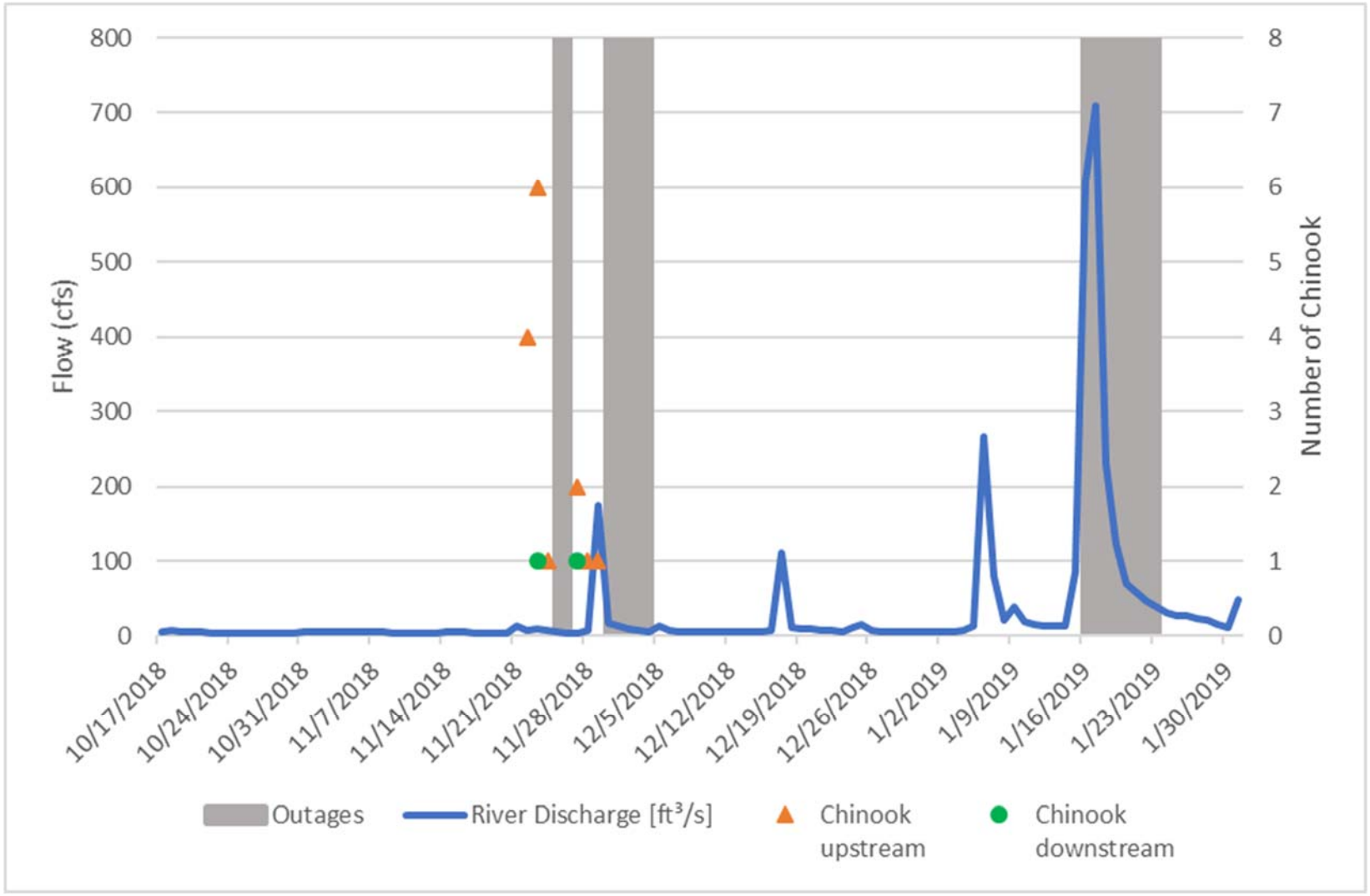


Figure 5: Chinook salmon detections per day (right y-axis) in relation to cubic feet per second (cfs) daily averages (left y-axis) on the Guadalupe River stream gage ALERT 5023b above Almaden Expwy. This graph only extends to January 30th as this is the extent of the Chinook salmon migration period.

DISCUSSION

No adult steelhead detections occurred during the monitoring period; however, it is possible that they moved through the fish ladder during the periods of time when the Vaki was non-operational. Per Moyle (2002), adult winter steelhead typically begin their upstream migration between December and March, peaking in January and February. The known peak of adult *steelhead* movement directly overlaps with the longest lapse in Vaki operation, when the conditions were too poor for the Vaki to operate for seven days. It is also possible that adult steelhead could have passed through the Vaki system but detections did not provide adequate videos or silhouettes to be identified to species and were therefore accounted for as “unknown fish”.

As previously mentioned, the Vaki is not designed to track movement of juvenile *O. mykiss*. The small size of the juvenile fish allows them to potentially swim back and forth between the weir bars or swim through the Vaki without triggering the scanners and thus avoid detection by the Vaki. Therefore, seasonal timing of migration and evaluation of numbers of individual *O. mykiss* was not conducted.

A total of 17 Chinook salmon were detected moving through the Vaki, but after analyzing the data for repeated detections the number of potentially unique fish was reduced to 13. Three of these detections had clipped adipose fins; however, given the size, timing, and direction of movement it was determined that these three detections were a single fish. Garcia-Rossi and Hedgecock (2002) determined that fish sampled from the Santa Clara Valley are most closely related to the Central Valley Fall run, and most similar to Feather River Hatchery fish. The hatchery systems in California use a fractional marking system (approximately 25% at Nimbus Fish Hatchery (Calfish 2018)) when applying coded wire tags and clipping adipose fins. Due to the small proportion of fin-clipped fish from the fractional marking system, it is likely that un-clipped Chinook salmon in the Guadalupe Watershed are of hatchery origin.

Additionally, a single Pacific lamprey was detected moving upstream; however, the confidence rating of the detection was low due to both a poor quality video and silhouette. Due to Pacific lampreys’ ability to latch onto walls and fit through small spaces, it is likely that additional Pacific lamprey were undetected by traversing around the Vaki system.

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Reports included:

2020 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed

2020 Guadalupe River Watershed Juvenile *Oncorhynchus mykiss* Fish Condition

Guadalupe River Watershed *Oncorhynchus mykiss* 2019 – 2020 Migration Monitoring Using Passive Integrated Transponder Tags

2020 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed



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Executive Summary

Valley Water has been conducting juvenile steelhead (*Oncorhynchus mykiss*) monitoring since 2004 as part of the downtown Guadalupe River Project. The monitoring was concluded in 2013, but Valley Water recommended the continuation and expansion of monitoring efforts to better understand *O. mykiss* numbers and distribution in the Guadalupe River Watershed. In 2013 the Guadalupe River Project's Adaptive Management Team (AMT) approved the recommendation (No. 136) to expand monitoring and in 2018 the National Marine Fisheries Service and California Department of Fish and Wildlife authorized the expansion of the monitoring under Section 10(a)1(A) take permit #16417-2R and Scientific Collecting Permit #11325, respectively.

In fall 2020, monitoring was conducted at 19 stations in the Guadalupe River Watershed, including stations in the Guadalupe River, Guadalupe Creek, Los Gatos Creek, Calero Creek, and Alamitos Creek. Due to dry conditions and the presence of homeless encampments and associated risk of exposure to COVID 19, some stations were not sampled in 2020. Multi-pass depletion backpack electrofishing was conducted at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Guadalupe River Watershed. Sixty-three appropriately sized *O. mykiss* (≥ 65 mm) were tagged with Passive Integrated Transponder (PIT) tags to study their movement within the Guadalupe River Watershed.

Juvenile *O. mykiss* were present in, Alamitos, Calero, and Guadalupe Creeks during fall 2020, with 24 (0.12 *O. mykiss*/m), 35 (0.29 *O. mykiss*/m), and 16 (0.08 *O. mykiss*/m) individuals captured in each creek, respectively. No *O. mykiss* were detected in Los Gatos Creek or Guadalupe River. Based on the size range of fish collected, it can be deduced that reproduction and successful summer rearing occurred, and multiple age classes were present.

Five species of native fish were captured within the Guadalupe Watershed including riffle sculpin (*Cottus gulosus*), prickly sculpin (*Cottus asper*), California roach (*Lavinia symmetricus*), Sacramento sucker (*Catostomus occidentalis*), and *O. mykiss.* Six species of non-native fish were observed amongst the five systems sampled, representing less than 2% of the total number of fish observed in 2020. These included mosquitofish (*Gambusia affinis*), largemouth bass (*Micropterus salmoides*), bigscale logperch (*Percina macrolepida*), inland silverside (*Menidia beryllina*), channel catfish (*Ictalurus punctatus*), and tule perch (*Hysterocarpus traskii*). The Guadalupe River and Los Gatos Creek had the highest percentage of non-natives (16.7% and 14.6%, respectively).

This juvenile rearing monitoring is part of a continuing effort to better understand *O. mykiss* distribution and abundance in the Guadalupe River Watershed. This report contains the results and analysis of the juvenile rearing monitoring conducted from 2004 – 2020.

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Appendices

Appendix A: 2019-2020 Guadalupe River Watershed Stream Temperature Monitoring

1. Introduction

The United States Army Corps of Engineers (USACE), in partnership with Valley Water, constructed both the Guadalupe River Project (Downtown Project) and Upper Guadalupe River Project (UGRP) on the Guadalupe River mainstem. These projects together extended from approximately Norman Y. Mineta San Jose International Airport to Blossom Hill Road to protect downtown San Jose from Guadalupe River flooding. To offset the impacts of constructing the Downtown Project, the Guadalupe River Project Mitigation and Monitoring Plan (Downtown Project MMP) specified that a variety of mitigation be undertaken, including restoration of Guadalupe Creek from approximately Almaden Expressway to Masson Dam (Corps 2001a). The Downtown Project MMP also described the monitoring methods and measurable objectives for determining the success of mitigation. This included 10 years of monitoring for juvenile rearing of federally threatened Central California Coast Steelhead (*Oncorhynchus mykiss*) at 12 stations in the mainstem Guadalupe River and eight stations within Guadalupe Creek to demonstrate whether the associated measurable objective was being met: "The Guadalupe River must continue to support juvenile rearing at a level that is consistent with pre-project conditions and environmental conditions not affected by the Guadalupe River Project" (Jones and Stokes, 2004). Stations GR001 to GR004 and GC001 to GC004 are the subset of stations within this report that have been consistently sampled since 2004. Detailed information on the sampling conducted between 2004 and 2017 can be found in the 2017 Guadalupe River Mitigation and Monitoring Report (Valley Water and Stillwater Sciences 2018; Valley Water 2019; Valley Water 2020).

Valley Water conducted the required juvenile rearing monitoring from 2004 to 2013, and the measurable objective was met in each year. Instead of ending the monitoring, Valley Water recommended continuing and expanding it to better understand juvenile *O. mykiss* distribution and densities, collect genetic information, and implement an *O. mykiss* tracking study using Passive Integrated Transponders (PIT), as well as to document the composition of other fish species in the watershed. In 2013, the Downtown Project Adaptive Management Team (Guadalupe AMT) approved the recommendation (No. 136) to continue juvenile rearing monitoring at five of the previous

monitoring stations on the Guadalupe River and expand the monitoring to 15 stations elsewhere in the watershed. However, the Downtown Project permits did not authorize juvenile rearing monitoring at additional stations. From 2013 to 2017 (with the exception of 2014), juvenile rearing monitoring continued at the original permitted stations (as flow conditions allowed) on Guadalupe River and Guadalupe Creek, while the permits for monitoring at additional stations were acquired. Ultimately, additional monitoring in the Guadalupe River Watershed was authorized under National Marine Fisheries Service (NMFS) Section 10(a)1(A) permit number #16417-2R and California Department of Fish and Wildlife (CDFW) Scientific Collecting Permit #11325 for Valley Water's Fisheries and Aquatic Habitat Collaborative Effort (FAHCE) Adaptive Fishery Management Baseline Data Collection Project. In 2018, Valley Water expanded the juvenile rearing monitoring to include areas outside of the Guadalupe River Project reaches as well as into Los Gatos Creek, Alamitos Creek, and Calero Creek.

To date, juvenile rearing monitoring results have been reported to the Guadalupe AMT in the annual Mitigation Monitoring Report (MMR) for the Guadalupe River Projects. Beginning in the Water Year (WY) 2018 MMR, monitoring results were reported in a stand-alone document to facilitate distribution to and review by FAHCE stakeholders as well as the Guadalupe River Projects' AMT. The 2020 results will continue in this fashion.

2. Methods

2.1 Station Selection

A total of 19 stations within the Guadalupe River Watershed were sampled between October 21 and November 20, 2020. These stations included a subset of the stations where monitoring was conducted in 2004 through 2017, as well as the expanded sites selected in 2018 to provide continuity from the previous monitoring effort on Guadalupe River and Guadalupe Creek and maintain a long-term dataset. The new stations where monitoring began in 2018 were selected using random stratified sampling as well as by selecting one area of interest on Alamitos Creek and one on Guadalupe River in 2020.

The 2018 monitoring report includes details associated with site selection (Valley Water 2019).

In 2020, three stations were sampled on Guadalupe River (Figure 1). Two of these stations have been sampled since 2004 (GR001 and GR003). Stations on the Guadalupe River mainstem located upstream of the Los Gatos Creek confluence (GR004, GR005, and GR006) were unable to be sampled this year due to low flows causing GR006 to be completely dry and GR004 and GR005 to be isolated pools. Station GR002 was unable to be sampled due to the presence of a large homeless encampment posing health and safety concerns. Station GRBONUS was added downstream of station GR001, at Skyport Drive, to increase the number of stations sampled on Guadalupe River since four of the repeatedly sampled stations were unable to be sampled this year.

Five stations were sampled on Guadalupe Creek, all of which were previously sampled in 2018 and 2019 (Figure 2). GC002 was unable to be sampled this year because the station was completely dry. GC001 was not connected to upstream habitat; however, the station still contained habitat that would support juvenile rearing. Station GC001, GC003, and GC004 have been sampled since 2004 and thus have more years of comparable data.

Three stations were sampled on Los Gatos Creek (LG001, LG003, and LG004), and these locations remained consistent with the 2018/2019 station locations (Figure 3). LG002 was unable to be sampled this year due to a large homeless encampment posing health and safety concerns.

On Alamitos Creek, all four stations sampled in 2018/2019 were resampled, as well as an additional rotating station (Figure 4). This additional site will rotate on a yearly basis and is primarily used to increase numbers of captured *O. mykiss* for PIT tag implantation. Yearly comparisons will not occur for this rotating station. This year, the additional site was located downstream of AC001.

Sampling on Calero Creek occurred at three stations, all of which were previously sampled in 2018 and 2019 (Figure 5).

Valley Water also operates temperature monitoring stations within the study areas and in other anadromous portions of the Guadalupe River and Guadalupe, Los Gatos, Alamitos, and Calero Creeks to provide continuous monitoring of habitat conditions and help inform the timing of juvenile rearing sampling. Details regarding stream temperature monitoring are provided in Appendix A.

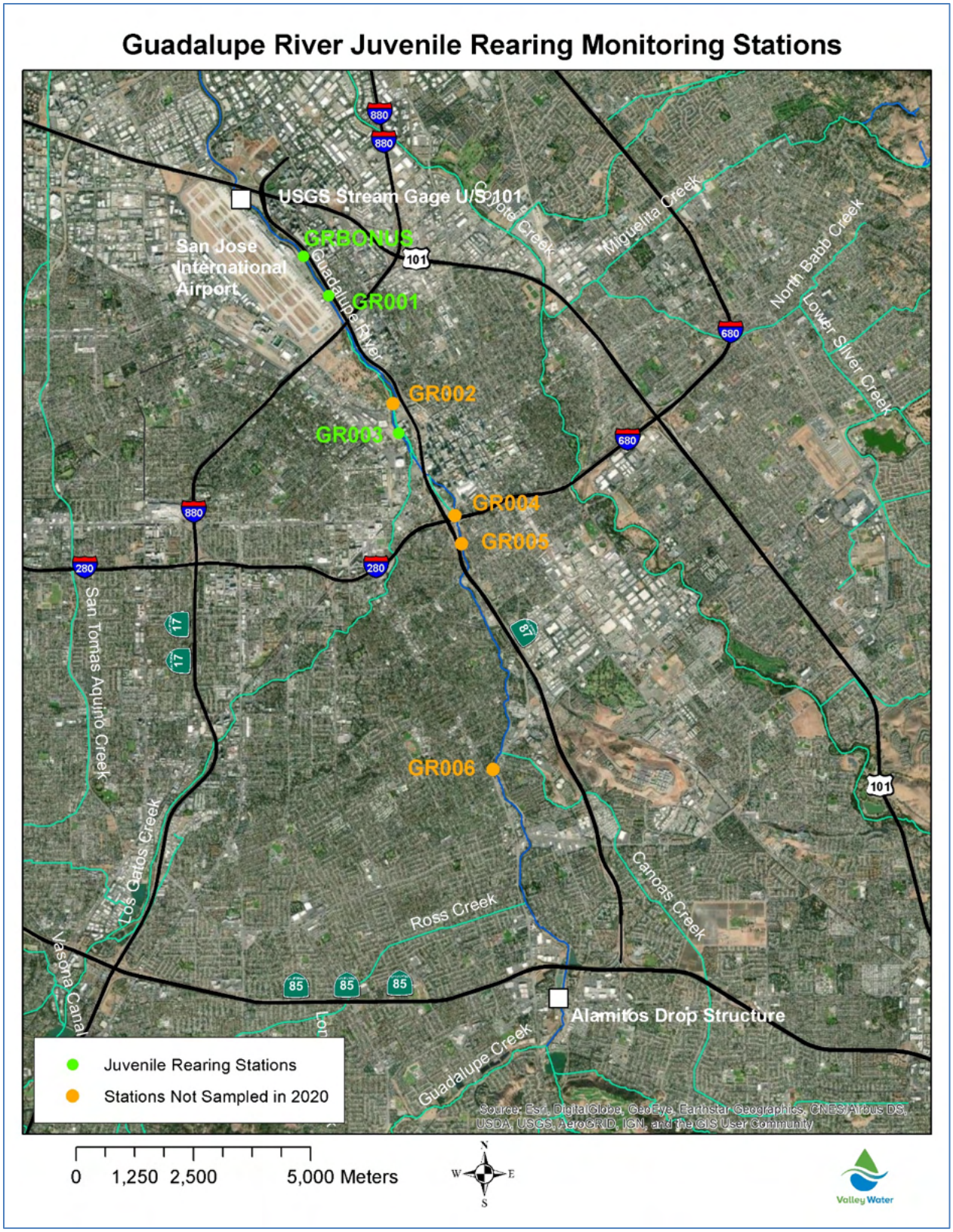


Figure 1. Guadalupe River juvenile rearing monitoring stations.

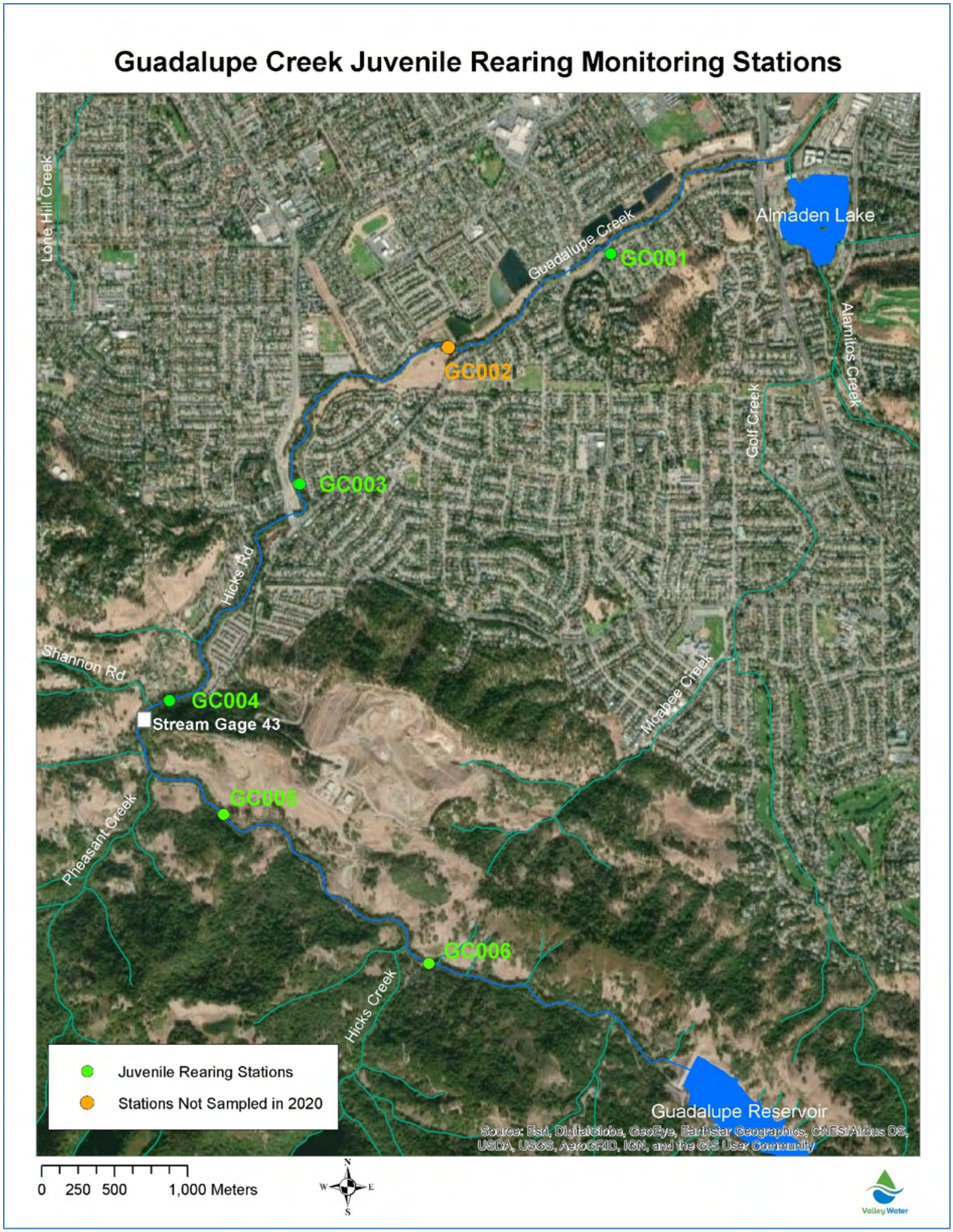


Figure 2. Guadalupe Creek juvenile rearing monitoring stations.

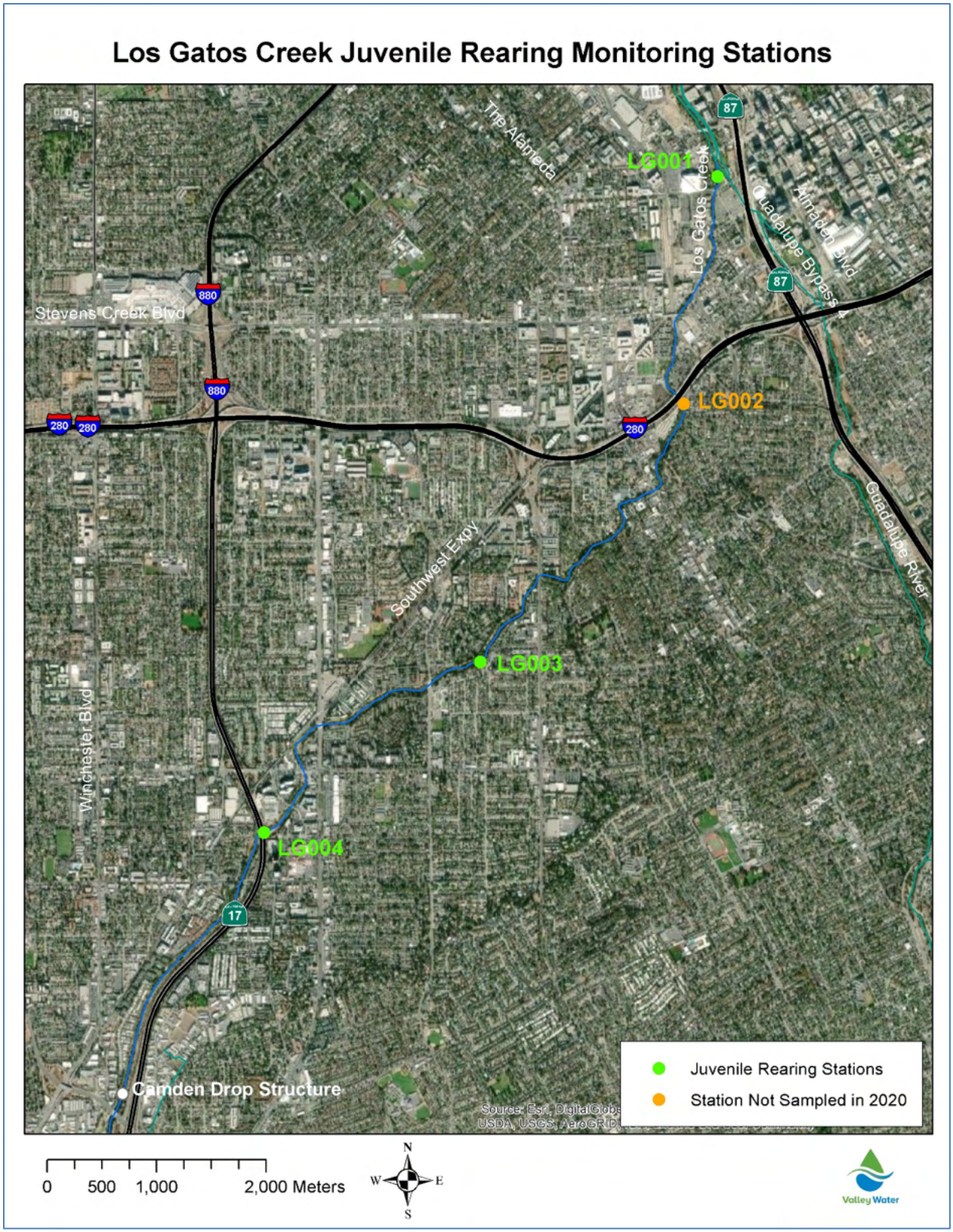


Figure 3. Los Gatos Creek juvenile rearing monitoring stations.

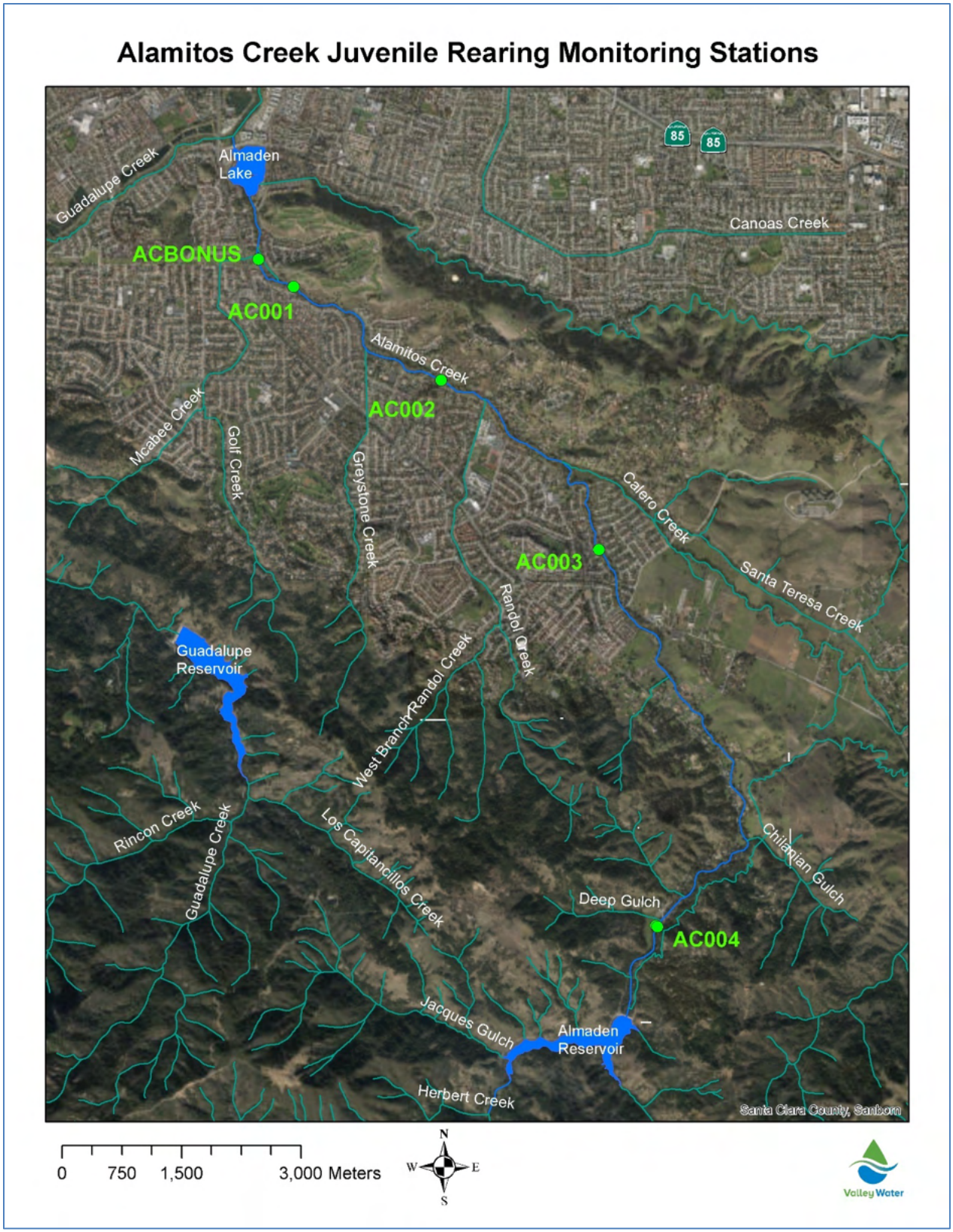


Figure 4. Alamitos Creek juvenile rearing monitoring stations.



Figure 5. Calero Creek juvenile rearing monitoring stations.

2.2 Sampling Methods

Each monitoring station ranged between 24.0 and 47.5 m in length. The target length was 40.0 m, but deviations in length occurred based on safety concerns and the ability to install and secure block nets or to avoid areas where electrofishing could not effectively be conducted (e.g., too deep). Each station included at least two distinct habitat types, described below. Multi-pass depletion backpack electrofishing (Johnson et al. 2007) was used at every monitoring station. This method allowed for consistency with previous juvenile rearing monitoring methods, the extrapolation of population estimates, and the sampling of a variety of habitat types.

Habitat Typing

Each monitoring station was habitat-typed following Ode (2007), using the classifications described in Table 1 as a guideline. Average wetted width and depth were estimated and the presence of any anthropogenic influences (bridge, dam, etc.) was noted. Prior to the start of sampling, ambient conditions (weather) were noted and water quality parameters (dissolved oxygen, conductivity, turbidity, and temperature) were collected at the downstream end of each sampling station. Ocular estimates of percent cover of macrophytes/emergent vegetation, boulders, woody debris, undercut banks, overhanging vegetation, submerged roots (live and dead), and artificial structures were recorded for each monitoring station (Table 2; Ode 2007). Each habitat feature was ranked on a 0 to 4 point scale, described in Table 2, with 0 being absent and 4 being a very heavy presence. Primary and secondary substrate types were determined based upon ocular estimates (Table 3; Ode 2007).

Table 1. Habitat type classifications (Ode 2007).

Habitat Type	Description
Cascades	Short, high gradient drop in streambed elevation often accompanied by boulders and considerable turbulence.
Falls	High gradient drop in elevation of the streambed associated with an abrupt change in the bedrock.
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles.
Riffles	Shallow sections where the water flows over coarse streambed particles that create mild to moderate surface turbulence.
Step-Run	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope.
Runs	Sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool.
Glides	A section of stream with little or no turbulence, but faster velocity than pools.
Pool	A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Table 2. Ocular estimate scale (Ode 2007).

Scale	0	1	2	3	4
Percent Coverage	0%	<10%	10-40%	40-75%	>75%
Descriptor	Absent	Sparse	Moderate	Heavy	Very Heavy

Table 3. Substrate classes (Ode 2007).

Particle Size	Size Category
Boulder	> 250 mm
Cobble	64-250 mm
Gravel	2.0-64 mm
Sand	<2.0 mm (gritty texture)
Silt/Clay	Not gritty
Bedrock	No individual particles

Electrofishing

Block nets were installed at both the upstream and downstream ends of each sampling reach to block fish immigration into and emigration out of sampling reaches. Block nets were secured with rebar and spreaders to hold the nets in place and keep the top of the nets above water, and large rocks were used to add extra security to the lead line and keep the bottom of the net flush with the channel bottom. Electrofishing then commenced from down- to upstream and worked laterally across the stream to ensure all portions of the wetted width were sampled. Smith-Root LR24 Backpack Electrofishing Units were used at all monitoring stations. Johnson et al. 2007 recommends that when portions of a creek exceed 7.0 m in width, two electrofishers be deployed to provide adequate coverage of the channel. However, this year a single electrofisher was deployed at each station to minimize the number of individuals on each team in order to reduce the risk of spreading COVID-19. The LR24 quick setup option was used to establish the initial power and waveform settings. The quick setup output was verified with conductivity readings and adjusted as appropriate. Electrofishers were run using direct current, at a frequency of 30 Hz, duty cycle of 12%, and voltage that ranged between 150 and 230 volts. Each electrofisher operator was flanked by two netters. Verbal communication and spatial awareness were used to ensure the entire width of the stream was covered. Triple-pass depletion electrofishing methods were deployed at all stations unless no fish were captured on both the first and second pass, in which case a third pass was not conducted. Fish captured were held in

dark colored 5-gallon buckets or live cars during each electrofishing pass prior to processing.

Fish Processing

Fish were held in aerated, dark-colored 5-gallon buckets during processing. Length measurements were recorded to the nearest millimeter at the fork of the tail (fork-length). For each pass, up to 30 individuals of each species were measured, and all additional individuals of that species were counted for a total number. All *O. mykiss* were measured regardless of number caught in a pass. Weights were recorded for *O. mykiss* to the nearest tenth of a gram using an Ohaus NVT22001.

Carbon dioxide (CO_2) was administered to *O. mykiss* using Alka-Seltzer Gold placed in a bucket of stream water in doses sufficient to induce light narcosis (1 tablet per 2.5 liters of stream water). *O. mykiss* were exposed to the anesthesia for no more than 5 minutes. *O. mykiss* were observed for listing, and upon listing were removed from the anesthetizing solution, weighed, measured, fin-clipped for a genetic sample, scanned to determine whether a PIT tag was present, and PIT tagged if large enough (≥ 65 mm fork-length) and the individual had not been previously tagged.

Fin clips from the caudal fin were taken for genetic analysis of all *O. mykiss*. Clips were 1-2 mm^2. Medical grade scissors used to collect the clips were sterilized between each use with an alcohol dilution with a final concentration of 60-80% isopropyl. Tissue samples were placed in sterile chromatography paper and placed in a labeled envelope denoting the field specimen number, species, stream, sample station ID, date, and fork-length. All tissue samples collected will be sent to the NMFS Southwest Fisheries Science Center for analysis once an adequate sample size is collected.

All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure. All *O. mykiss* 65 mm in fork-length or greater, which had not been previously tagged, received a PIT tag. Biomark single-use preloaded needles were used in the tagging process. *O. mykiss* with fork-

lengths ranging from 65 mm to 149 mm received 12 mm half-duplex PIT tags. *O. mykiss* with fork-lengths of 150 mm or greater received 23 mm tags[1]. All PIT tag numbers and associated biological data for each fish tagged by Valley Water can be found in the Guadalupe River Watershed PIT tag monitoring report (Valley Water 2021).

Once processing was completed, all fish were transferred to an in-channel live car for recovery. The live car was placed outside of the sampling reach and outside of the field of current from the electrofisher in an area with flow, shade, and low relative turbidity from the time processing ended until the sampling event was complete to allow fish time to recover and to prevent processed fish from re-entering the sample reach. All fish were released after the final pass.

2.3 Data Analysis

MicroFish 3.0 was used to calculate population estimates for each station using a maximum-likelihood iterative process (MLIP); the associated standard errors and 95% confidence intervals (95% CI) are reported herein. This method uses the number of fish captured (n) and the difference in capture between electrofishing passes (i.e., depletion rate) to calculate an estimate of individuals likely to have been present but not captured, thus generating a population estimate (N) for each species for each station. Population estimates are restricted to the sampled areas and are only an index of the overall population. If the number of a particular species was too low (i.e., only one fish was captured) or all individuals of a particular species were captured on the first pass (with no individuals of that species captured on subsequent passes), then MLIP population estimate could not be produced. If the lower confidence interval was less than the total catch it was set equal to total catch, as it is certain at least that many fish were present in the sampling reach. These calculations assume fish emigration and immigration were prevented by the erection of upstream and downstream block nets, that shocking efficiency did not change between passes and that staff did not become more efficient using the equipment, nor did fish learn to avoid the electrical field between passes.

[1] The permits allow for fish greater than 100 mm to be tagged with 23 mm tags, but to be conservative with the fishes' welfare, Valley Water increased the minimum size to 150 mm.

Because sampling reach lengths may vary by station or by year, results have been standardized to catch per unit effort (number of fish per meter) to enable comparison of the long-term dataset.

3. Results and Discussion

3.1 Guadalupe River

Sampling occurred at three stations in Guadalupe River on November 19 and 20, 2020. The weather was sunny and clear with no precipitation. Flows at the United States Geological Survey (USGS) stream gage upstream of Highway 101 (USGS #11169025), which provides the best representation of the sampled locations (juvenile rearing stations GR001,GR003, and GRBONUS), were approximately 27.1 cubic feet per second (cfs) during both sampling days.

GR001

GR001 has been sampled annually during the 2004 to 2019 monitoring effort (with the exception of no sampling occurring in 2014). This station is low gradient. A dense riparian corridor is present (Figure 6), but the channel is situated between two levees and urban development. The monitoring station was 38.0 m in length with an average wetted width of 8.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and glide. Riffle habitat made up 58% of the sampling area, with the glide contributing 42%. The primary substrate was gravel with a secondary substrate of silt. Water quality and habitat complexity at the time of sampling are summarized in Table 4.



Figure 6. Photos of station GR001, looking upstream (left) and looking downstream (right).

Table 4. GR001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
747.00	16.16	6.59	15.90			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	0	1	0	3	1	0

Fish captured and associated population estimates are summarized in Table 5. Three species of fish were captured: prickly sculpin (*Cottus asper*), California roach (*Lavinia symmetricus*), and mosquitofish (*Gambusia affinis*). No *O. mykiss* were captured.

Table 5. Number captured and population estimates at GR001.

Species	Native	n	N	SE	95% CI
California roach	Yes	5	13	37.54	5-95
Mosquitofish	No	2	2	1.88	2-26
Prickly sculpin	Yes	11	11	1.27	11-14

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Native fish, including California roach and prickly sculpin, made up most of the fish captured at station GR001, with prickly sculpin being the most abundant species (n=11). Two individuals of the non-native mosquitofish were captured. The MLIP population estimate indicates that the number of California roach is likely higher than what was observed during sampling.

Station GR001 has 16 years of comparable data (no sampling occurred in 2014). Figure 7 shows the standardized capture of *O. mykiss* between 2004 and 2020. This station has historically had low production of *O. mykiss*: of the 16 years of sampling data, *O. mykiss* were only collected in four of the years, and the highest capture rate (in 2005) was 0.10 *O. mykiss*/m. *O. mykiss* have not been observed at this station since 2012. The average *O. mykiss* capture rate for GR001 in 2020 is 0.02 *O. mykiss*/m. These results indicate that *O. mykiss* occurrence in this downstream portion of the Guadalupe River is very low, inconsistent, and potentially that recolonization has not occurred after the severe drought conditions that occurred from 2014 to 2016.

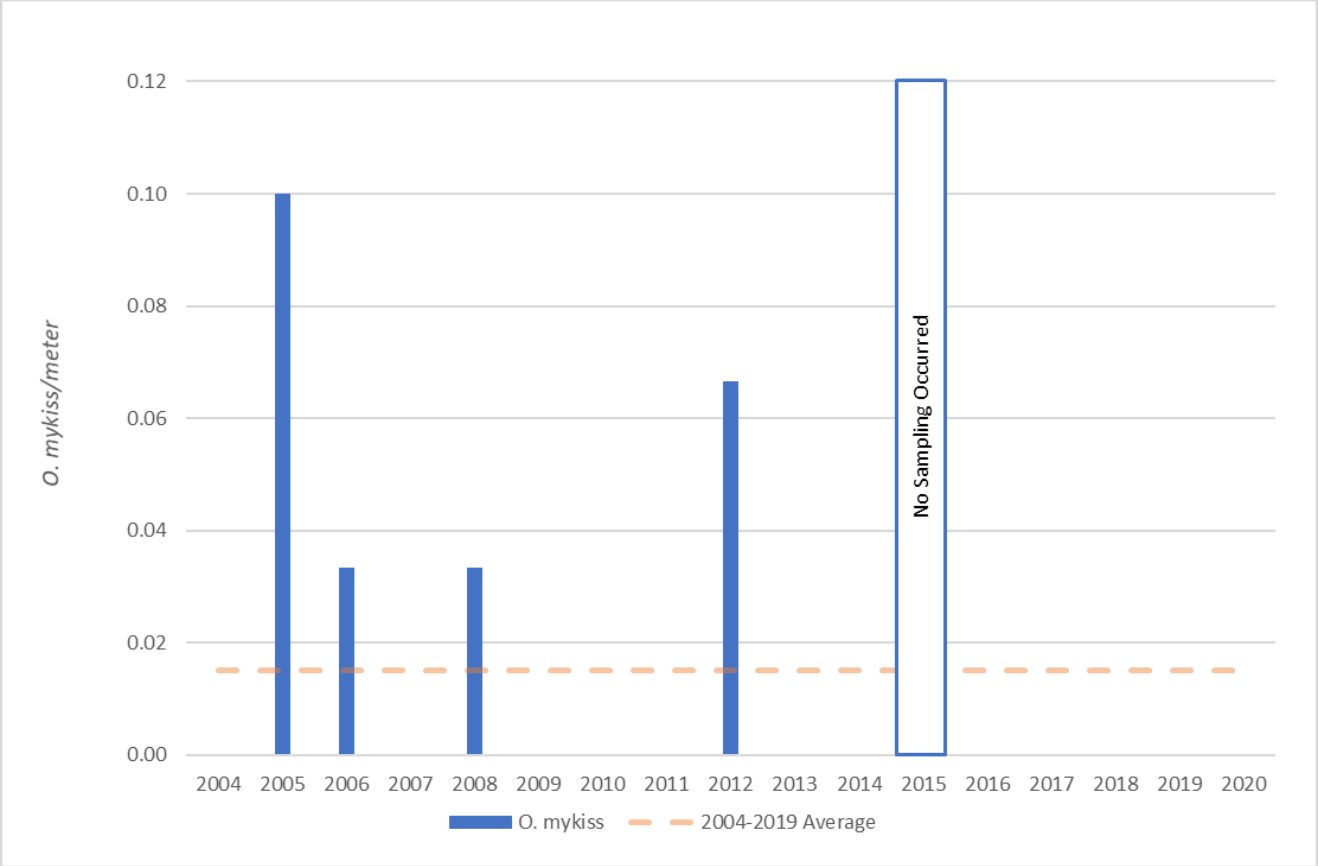


Figure 7. Station GR001 standardized *O. mykiss* capture 2004-2020. Dashed line indicates the average density from 2004-2019 from this station.

GR003

GR003 has been sampled annually from 2004 to 2019 (with the exception of 2014-2015). This sampling station includes the St. John Street Passage Remediation Project, which created riffle habitat and added anchored large woody debris to the channel. A portion of the station was under the St. John Street Bridge. The monitoring station was 47.5 m in length with an average wetted width of 7.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and run (Figure 10). The riffle made up 68% of the station with the run making up the remaining 32%. The primary substrate was large cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity are included in Table 8.



Figure 8. Photos of station GR003, looking upstream (left) and looking downstream (right).

Table 6. GR003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
628.00	14.66	8.52	10.10			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	2	1	1	1	0	4*
*Artificial structures in this reach include the design riffle and installed large woody debris.						

Three species of fish were captured: California roach, largemouth bass (*Micropterus salmoides*), and prickly sculpin. No *O. mykiss* were captured. The most abundant species encountered were native California roach (n=4) and non-native largemouth bass (n=4). Fish captured and associated population estimates are summarized in Table 9. An adult Chinook salmon (*Oncorhynchus tshawytscha)* was visually observed moving upstream during the third pass. The individual was not captured nor shocked during the sampling. Electrofishing immediately ceased upon observing the fish to avoid interaction. Due to the occurrence of the Chinook salmon, the most upstream half of the station was not shocked or sampled during the third pass.

Table 7. Number captured and population estimates at GR003.

Species	Native	n	N	SE	95% CI
California roach	Yes	4	4	0.97	4-7
Largemouth bass	No	4	4	0.97	4-7
Prickly sculpin	Yes	2	2	0.38	2-7

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

The MLIP does not indicates that the number of fish present in the sampling reach was likely higher than the number of fish captured for any of the species observed. It is possible that more fish were present, but due to the width and velocity in the reach they may have evaded capture.

Station GR003 has 15 years of comparable data. Figure 9 shows the standardized capture of *O. mykiss* between 2004 and 2020. Of the 15 years of data, *O. mykiss* were collected in eight of the years sampled and the highest density was observed in 2012 at 0.43 *O. mykiss*/m. The average *O. mykiss* density based on the 2004 to 2019 dataset for this station is 0.10 *O. mykiss*/m.

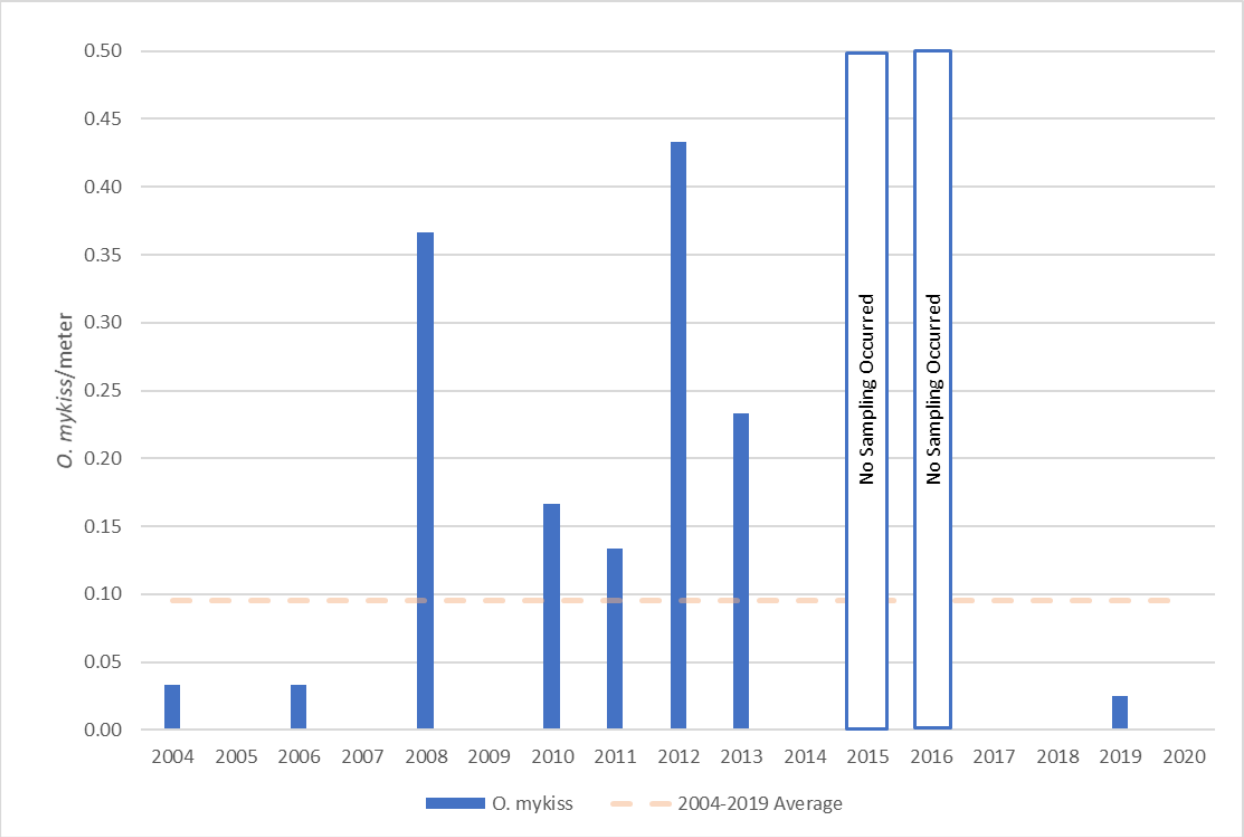


Figure 9. Station GR003 standardized *O. mykiss* capture 2004-2020. Dashed line indicates the average density from 2004-2019 from this station.

GRBONUS

GRBONUS was a new sampling station in 2020 located near Skyport Drive. This site was added due to the inability to sample most of the other previously sampled sites on the Guadalupe River mainstem this monitoring year. The river was spot-checked between GR001 and GR003 and no suitable sites were available for sampling due to deep pools or high velocities precluding block net installation and/or health and safety concerns. This location was the next available site with suitable habitat and was the most downstream station sampled on the Guadalupe River. The monitoring station was 37.0 m in length with an average wetted width of 7.0 m and an average depth of 0.4 m. Habitat within the station was 78% riffle and 22% run (Figure 13). The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 10.



Figure 10. Photos of station GRBONUS, looking upstream (left) and looking downstream (right).

Table 8. GRBONUS water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
800.00	15.33	8.19	12.80

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	1	0	1	0	0	3

Two species of fish were captured, both native: California roach and Sacramento sucker (*Catostomus occidentalis*). The most abundant species encountered was California roach (n=25). Fish captured and associated population estimates are summarized in Table 11. The MLIP did not indicate the calculated population estimate as higher than what was observed. No *O. mykiss* were captured at this monitoring station.

Table 9. Number captured and population estimates at GRBONUS.

Species	Native	n	N	SE	95% CI
California roach	Yes	25	25	0.99	25-27
Sacramento sucker	Yes	1	1	0.00	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

This was the first year of sampling at this location; therefore, station GRBONUS does not have any years of comparable data.

Guadalupe River Discussion

No *O. mykiss* were collected at any of the stations sampled on the Guadalupe River mainstem in 2020. Based on the previous Guadalupe River Project monitoring efforts (2004-2019), it is not uncommon for this species to be absent or in low abundance at individual monitoring stations on the mainstem Guadalupe River. Since initiating sampling in 2004, no monitoring station in the Guadalupe River has consistently captured *O. mykiss*. In the 2019 sampling effort a single *O. mykiss* was captured after a four-year span where no *O. mykiss* were detected within the Guadalupe River.

There have been no obvious changes in physical habitat on the Guadalupe River that would have triggered the decreased *O. mykiss* capture rates over the last few years. All stations sampled had some sort of habitat complexity (i.e., undercut banks, large woody debris, or submerged roots) that could be used as *O. mykiss* refugia, and riffle habitat that should support fast-water feeding requirements. The measurable objectives for streamside vegetation in the Downtown Project are being met, and other fisheries monitoring indicators, such as suitable habitat area (for juvenile *O. mykiss*), have indicated that habitat is available and consistent with unaltered index reaches (Valley Water and Stillwater Sciences 2020). Previous MMRs have discussed the influence that sampling timing appears to have on the number of *O. mykiss* detected in mainstem Guadalupe River. Higher numbers of *O. mykiss* were observed in years that sampling occurred after a rain event, but in each year between 2004 and 2013 *O. mykiss* were detected in some portion of the Guadalupe River (Valley Water and Stillwater Sciences 2013). In 2019, sampling occurred after a storm in September that raised the Guadalupe River to approximately 100 cfs. The capture of the one *O. mykiss* on the Guadalupe River in 2019 may have been a result of this storm and supports this hypothesis.

Monitoring efforts in 2020 continue to show patterns in the capture of native fish that add to the evidence that fish populations have not rebounded after the severe drought conditions from 2014 to 2016. Prior to 2014, the average annual catch of all native fish in the four consistently sampled stations on the Guadalupe River was 4.48 fish/m (California roach were most abundant). In 2015 and 2016, some stations were completely dry or yielded zero fish . From 2015 to 2019 the average annual catch of all native fish was 0.89 fish/m. In 2020 the average density of native fish at the two consistently sampled stations (GR001 and GR003) was 0.26 fish/m. Although this was only data from two stations, instead of the four repeatedly sampled stations, this is still less than half of the native fish captured from 2015 to 2019. The two other repeatedly sampled stations on Guadalupe River were unable to be sampled due to a homeless encampment posing health and safety risks at GR002 and extremely low flows and poor water quality at GR004. This was a decline from the 2.16 fish/m captured in 2019.This is also significantly lower than the post-drought average from 2015 to 2019. .

3.2 Guadalupe Creek

Sampling occurred at five stations on Guadalupe Creek on October 21, October 22, and November 18, 2020. All sampling days were sunny and clear. Flows at the four stations upstream of Masson Dam on Guadalupe Creek (GC003 – GC006), based on ALERT Gage 5017 - Guadalupe Creek below Guadalupe Reservoir, were between 1.0 and 1.1 cfs. Flows at the two stations downstream of Masson Dam (GC001 and GC002), based on ALERT gage 5114 Masson Fish Ladder - Low Flow Only, were recorded as 0.0 cfs. GC002 was not sampled this year because the stretch experienced a dry back. GC001 was wetted from ground water influence but isolated from the upstream reaches of Guadalupe Creek; however, it was still deemed valuable to sample.

GC001

GC001 was the most downstream station sampled and was monitored annually during the 2004 to 2020 monitoring period (except for 2014 and 2015). This monitoring station is surrounded by urban residential housing and falls within a mitigation reach for the Downtown Project, where extensive geomorphic and riparian restoration was completed

in 2002. The monitoring station was 35.0 m in length with an average wetted width of 3.0 m and an average depth of 0.20 m. Two habitat types were present within the station: riffle and run (Figure 11). Riffle habitat made up 77% of the sampled area and run habitat made up the remaining 23%. The primary substrate was silt with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 10.



Figure 11. Photos of station GC001, looking upstream (left) and looking downstream (right).

Table 10. GC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
113.00	17.66	7.30	28.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	0	1	1	3	1	0

Three species of fish were captured during the survey: *O. mykiss,* prickly sculpin, and California roach. Only a single individual of each species was captured. The one *O. mykiss* captured at GC001 was large enough to be PIT-tagged. Fish captured and

associated population estimates are summarized in Table 11. The MLIP did not indicate higher population numbers than what was captured for each of the species captured. All the fish captured in the reach were native.

Table 11. Number captured and population estimates at station GC001.

Species	Native	n	N	SE	95% CI
California roach	Yes	1	1	1.73	1-1
Prickly sculpin	Yes	1	1	0.00	1-1
O. mykiss	Yes	1	1	0.00	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC001 has 15 years of comparable data. No data was collected in this reach in 2014 or 2015. Figure 18 shows the standardized capture of *O. mykiss* between 2004 and 2020. In most years *O. mykiss* were captured at this station. The highest capture rate occurred in 2006 with 0.20 *O. mykiss*/m. The average *O. mykiss* density at this site between 2004 and 2019 (excluding years when no sampling occurred) was 0.05 *O. mykiss*/m. The density during the 2020 monitoring was 0.03 *O. mykiss/*m. This is below the 2004 to 2019 average density and a decrease from 2019, but consistent with 2018. Results indicate that juvenile rearing in this portion of Guadalupe Creek is variable, but following the 2014 drought conditions and dry-backs of 2015, *O. mykiss* have consistently utilized this habitat since 2017. A more detailed analysis of *O. mykiss* capture data is provided in the “Guadalupe Creek Discussion” section later in this document.

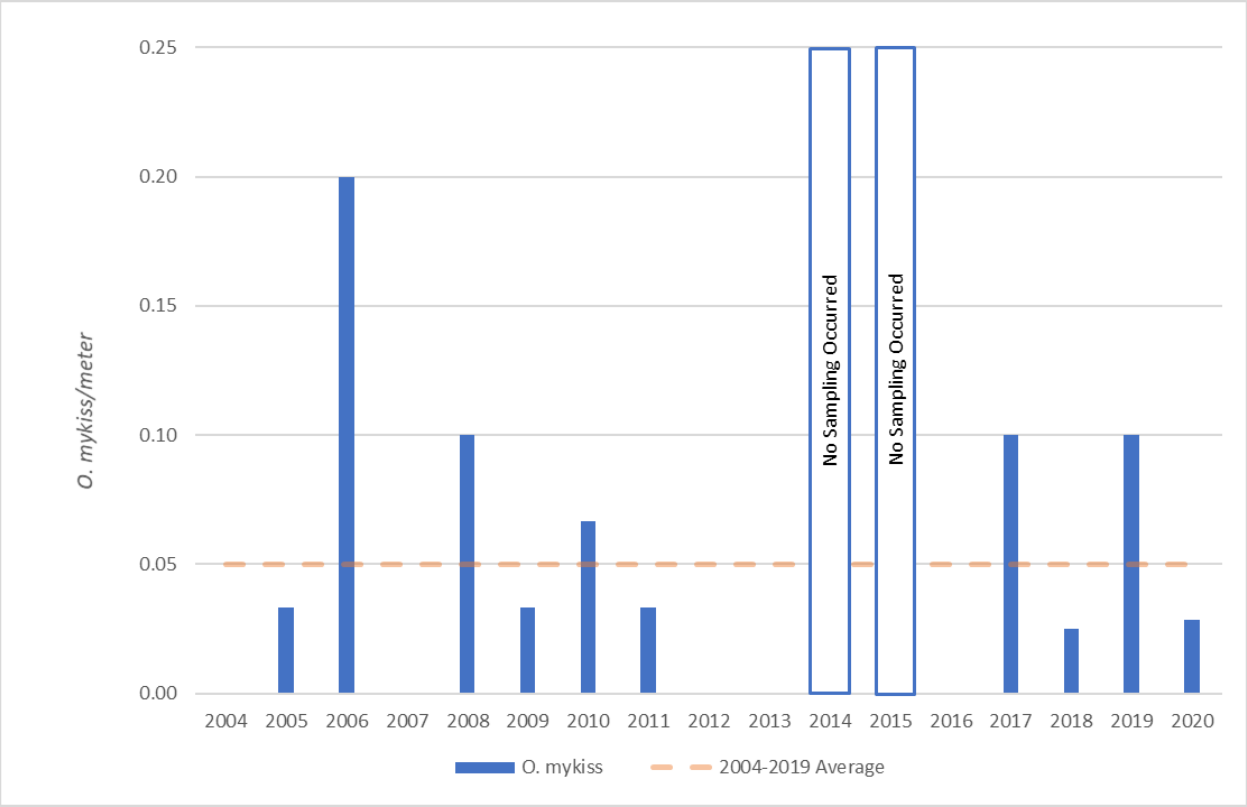


Figure 12. Station GC001 standardized *O. mykiss* capture 2004-2020. Dashed line indicates the average density from 2004-2019 from this station.

GC003

With the exception of 2014, this station was sampled in every year during the previous monitoring effort from 2004 to 2019. The station is upstream of Masson Dam, and is in an urban residential area. The monitoring station was 40.0 m in length with an average wetted width of 1.75 m and an average depth of 0.25 m. Two habitat types were present within the station: riffle and run (Figure 13). Habitat at the station was 48% riffle and 52% run. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 12.



Figure 13. Photos of station GC003, looking upstream (left) and looking downstream (right).

Table 12. GC003 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
525.00	15.01	9.75	3.50			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	0	0	1	3	2	0

Three species of fish were captured during the survey: *O. mykiss*, California roach, and riffle sculpin (*Cottus gulosus*). The most abundant species encountered was California roach (n=75). The one *O. mykiss* captured was ≥ 65 mm and thus was PIT-tagged prior to being released. Fish captured and associated population estimates are summarized in Table 13.

In station GC003 the MLIP indicates that the number of California roach and riffle sculpin are likely higher than what was captured. The MLIP did not indicate that the *O. mykiss* population was higher than observed. All the fish captured in the reach were native.

Table 13. Numbered captured and population estimates at station GC003.

Species	Native	n	N	SE	95% CI
California roach	Yes	75	134	47.14	75-227
O. mykiss	Yes	1	1	0.00	1-1
Riffle sculpin	Yes	49	51	2.23	49-55

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC003 now has 16 years of comparable data. Figure 22 shows the standardized capture of *O. mykiss* between 2004 and 2020. No sampling occurred in 2014. *O. mykiss* were captured at this station in all but four years. This reach did not experience dry-backs in 2015, but flow conditions were low and no *O. mykiss* were captured in 2015 or 2016. In 2017 *O. mykiss* returned, but in low density. The average *O. mykiss* density at this site between 2004 and 2019 (excluding years when no sampling occurred) was 0.15 *O. mykiss*/m. In 2020 the observed density was 0.03 *O. mykiss*/m. A more detailed analysis of *O. mykiss* capture data is provided in the "Guadalupe Creek Discussion" section later in this document.

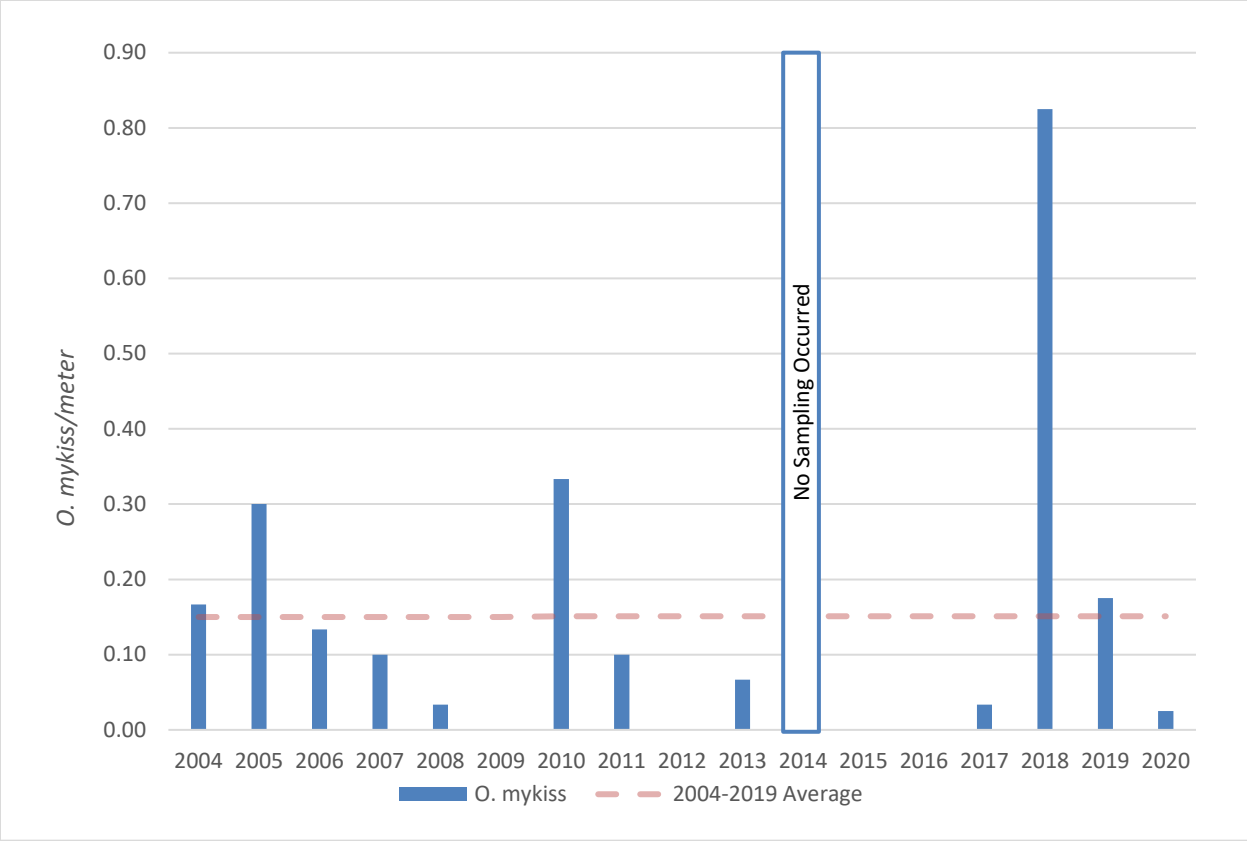


Figure 14. Station GC003 standardized *O. mykiss* capture 2004-2020. Dashed line indicates the average density from 2004-2019 from this station.

GC004

GC004 was sampled during the previous monitoring effort between 2004 and 2019. The station is situated amongst rural residential areas. The monitoring station was 40.0 m in length with an average wetted width of 3.0 m and an average depth of 0.25 m. Two habitat types were present within the station: riffle and run (Figure 15). Habitat at the station was 38% riffle and 62% run. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity can be seen in Table 14.



Figure 15. Photos of station GC004, looking upstream (left) and looking downstream (right).

Table 14. GC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
489.00	15.85	9.63	3.40			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
0	1	1	2	3	1	0

Three species of fish were captured during the survey: *O. mykiss*, California roach, and riffle sculpin. The most abundant species encountered was riffle sculpin (n=98). Six *O. mykiss* were captured during the sampling effort, four of which were large enough to be PIT-tagged prior to being released. Fish captured and associated population estimates are summarized in Table 15.

Table 15. Number captured and population estimates at station GC004.

Species	Native	n	N	SE	95% CI
California roach	Yes	22	27	6.29	22-40
O. mykiss	Yes	6	6	0.14	6-6
Riffle sculpin	Yes	98	102	3.15	98-108

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station GC004 has 16 years of comparable data. Figure 16 shows the standardized capture of *O. mykiss* between 2004 and 2020. In all but three years, *O. mykiss* were captured at this station. No sampling occurred in 2014. This reach did not experience dry-backs in 2015, but flow conditions were low and no *O. mykiss* were captured in 2015 or 2016. In 2017 *O. mykiss* returned. The highest density of *O. mykiss* occurred in 2005 at 1.03 *O. mykiss*/m. This was the highest density recorded at any station during the entire 15-year monitoring period. The average *O. mykiss* density at this site between 2004 and 2019 was 0.42 *O. mykiss*/m. The density during the 2020 monitoring was lower than the average from previous years' data collection efforts at 0.15 *O. mykiss*/m. The density observed in 2020 was slightly lower than in 2018 and 2019. The MLIP did not predict *O. mykiss* populations higher than what was captured. Though the observed densities are below average, the reach still appears to consistently support rearing. A more detailed analysis of *O. mykiss* capture data is provided in the "Guadalupe Creek Discussion" section later in this document.

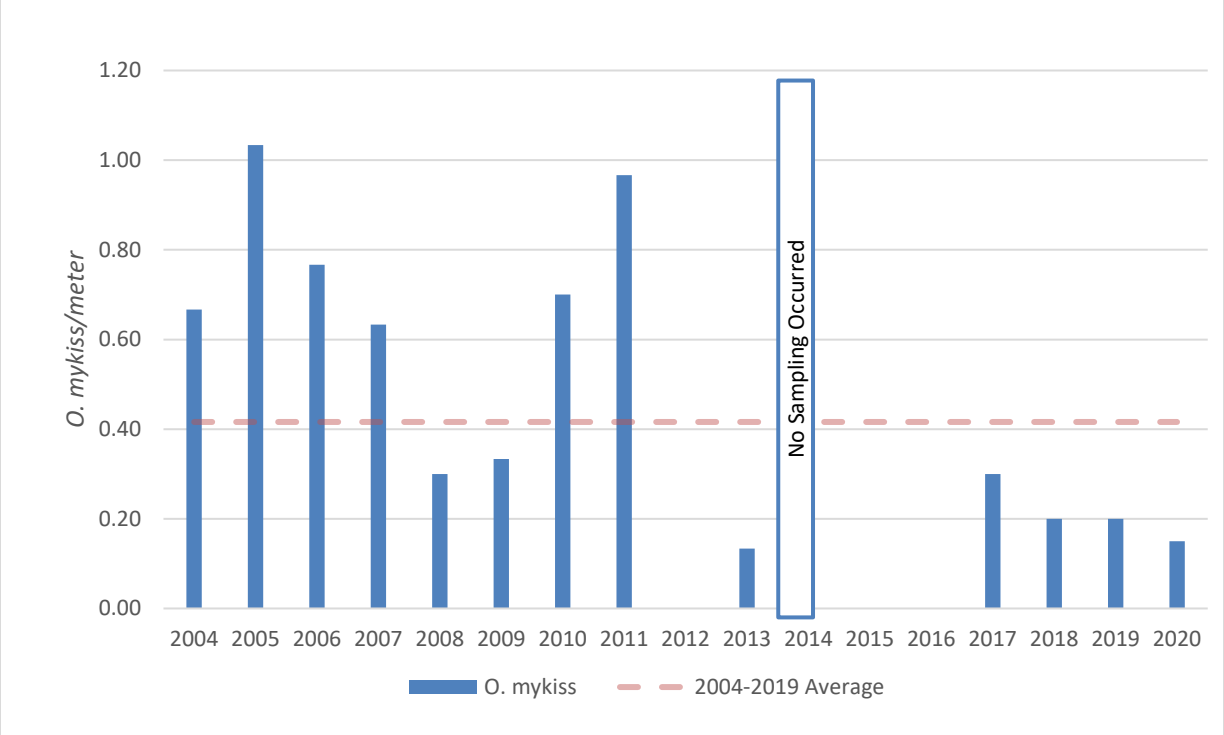


Figure 16. Station GC004 standardized *O. mykiss* capture 2004-2020. Dashed line indicates the average density from 2004-2019 from this station.

GC005

GC005 was part of the expanded monitoring effort that started in 2018; therefore, this is only the third year of data collection at this station. The station is surrounded by limited residential housing, with the Waste Management – Guadalupe Rubbish Disposal Facility to the east, and open space to the west. The monitoring station was 40.0 m in length with an average wetted width of 2.0 m and an average depth of 0.25 m. Three habitat types were present within the station: riffle, run, and pool (Figure 17). The habitat was 63% riffle, 25% run, and 12% pool. The primary substrate was cobble with a secondary substrate of boulders. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 16.



Figure 17. Photos of station GC005, looking upstream (left) and looking downstream (right).

Table 16. GC005 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
450.00	15.15	10.48	3.90

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
0	3	1	1	3	1	0

Two species of fish were captured during the survey: *O. mykiss* and riffle sculpin. The most abundant species encountered was riffle sculpin (n=53). Seven *O. mykiss* were captured during the sampling effort, five of which were ≥ 65 mm and were PIT tagged prior to being released. One *O. mykiss* (68 mm in fork-length), did not survive processing and was reported as a mortality. Fish captured and associated population estimates are summarized in Table 16. For station GC005 the MLIP indicates that the number of riffle sculpin is likely higher than what was captured.

Table 17. Number captured and population estimates at station GC005.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	7	7	0.58	7-8
Riffle sculpin	Yes	53	55	2.29	53-60

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

At station GC005, a slightly lower density of *O. mykiss* was captured in 2020 compared to 2019. This station had an observed and estimated density of 0.18 *O. mykiss*/m. Figure 18 shows the standardized capture of *O. mykiss* between 20018 and 2020. A more detailed analysis of *O. mykiss* capture data is provided in the “Guadalupe Creek Discussion” section later in this document.

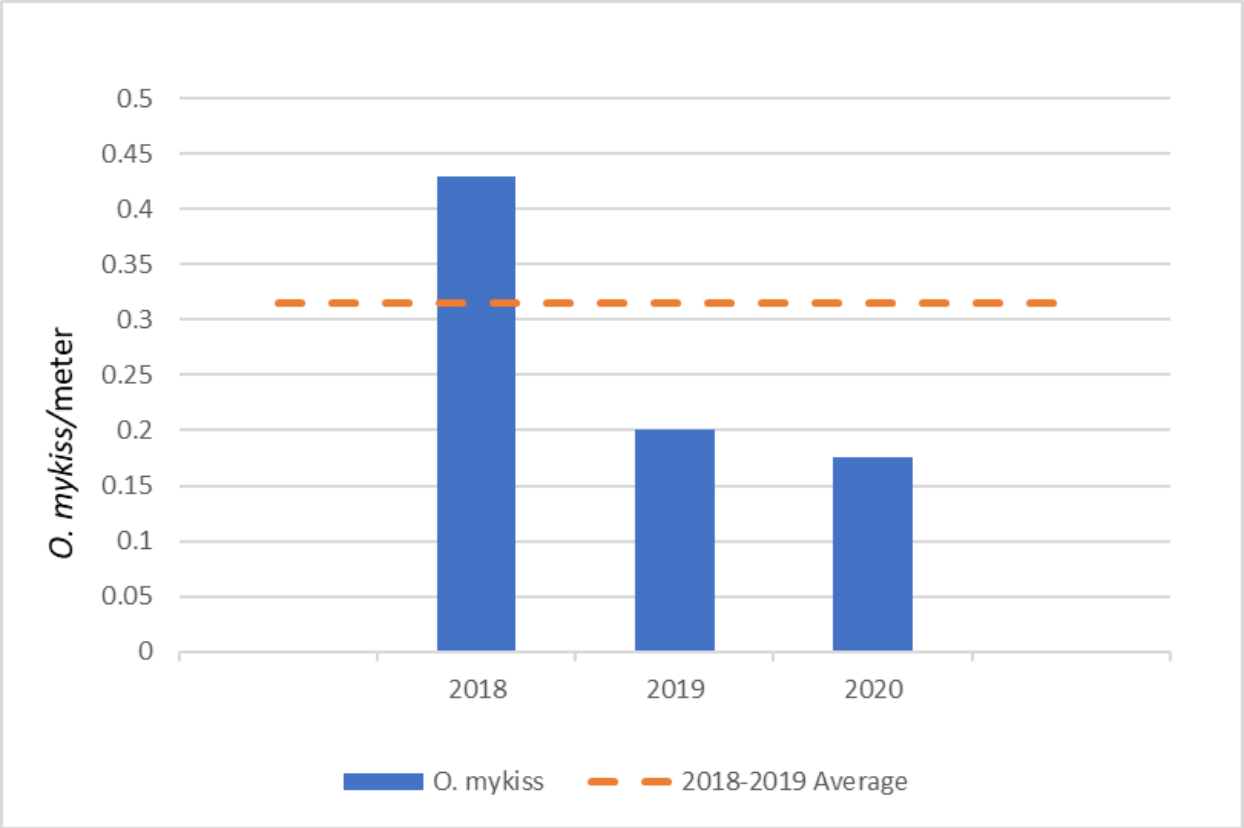


Figure 18. Station GC005 standardized *O. mykiss* capture 2018-2020. Dashed line indicates the average density from 2018-2019 from this station.

GC006

GC006 was part of the expanded monitoring effort started in 2018. The station is surrounded by limited rural residential housing and open space to the south, and was the most upstream station sampled. The monitoring station was 40.0 m in length with an average wetted width of 2.0 m and an average depth of 0.25 m. Three habitat types were present within the station: riffle, run, and pool (Figure 19). The riffle habitat made up 37.5%, the run 37.5%, and the pool the remaining 25%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 18. Dissolved oxygen was not collected at this station due to issues with calibration of the water quality instrument.



Figure 19. Photos of station GC006, looking upstream (left) and looking downstream (right).

Table 18. GC006 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
465.00	15.65	-	21.30			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	0	2	2	3	3	0

Three species of fish were captured during the survey: *O. mykiss*, Sacramento sucker, and riffle sculpin. The most abundant species encountered was riffle sculpin (n=11). One *O. mykiss* was captured and PIT tagged during the sampling effort. Fish captured and associated population estimates are summarized in Table 19. The MLIP did not provide population estimates higher than what was observed for any of the species captured.

Table 19. Number captured and population estimates at station GC006.

Species	Native	n	N	SE	95% CI
O. mykiss	Yes	1	1	0.73	1-1
Sacramento sucker	Yes	3	3	0.27	3-4
Riffle sculpin	Yes	11	11	1.27	11-14

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

This was the third year of sampling at this station so no long-term comparisons over time can be made, but the 2020 results for this station were lower than what was observed in 2018 and 2019. This station had an observed density (based on n) of 0.03 *O. mykiss*/m. (Figure 20). A more detailed analysis of *O. mykiss* capture data is provided in the "Guadalupe Creek Discussion" section later in this document.

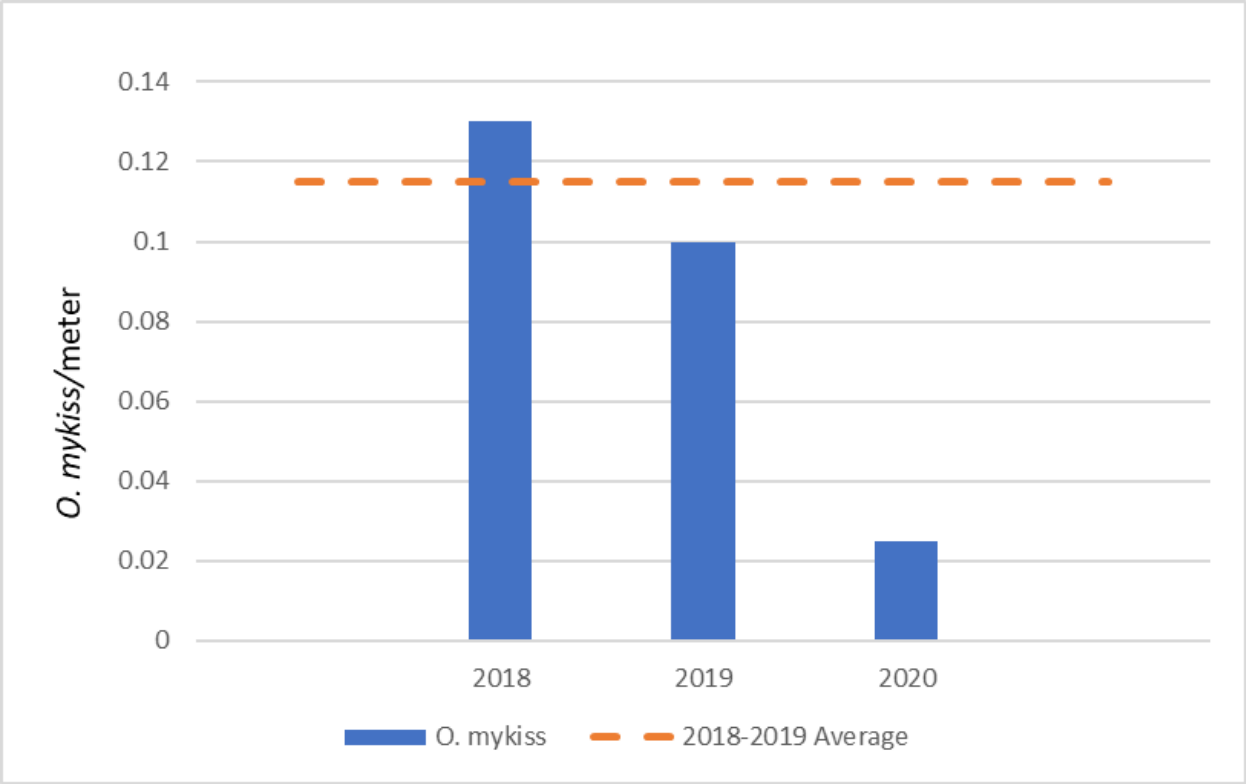


Figure 20. Station GC006 standardized *O. mykiss* capture 2018-2020. Dashed line indicates the average density from 2018-2019 from this station.

Guadalupe Creek Discussion

Guadalupe Creek supports five species of native fish (*O. mykiss*, California roach, prickly sculpin, riffle sculpin, Sacramento sucker) with multiple age classes of *O. mykiss.* No non-native species were captured during this sampling effort. Based on the results of the 2020 sampling, Guadalupe Creek continues to support rearing of *O. mykiss*. A total of 16 *O. mykiss* was collected in the five monitoring stations. MLIP did not predict the number of *O. mykiss* present to be higher than what was captured. Fork-lengths ranged from 56 mm to 184 mm (Figure 21). Growth rates of juvenile *O. mykiss* in

California are highly variable and are dependent on temperature, food availability, seasonal flow, and population densities/competition (Moyle 2002). According to Moyle (2002), in small streams with low summer flows, such as Guadalupe Creek, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith and Leicester (2016) aged 32 fish from Guadalupe Creek and found that young-of-the-year *O. mykiss* ranged from 85–114 mm, and fish in their second year ranged from 110–195 mm. This is a faster growth rate than predicted by Moyle (2002), but this is expected in warmer, more productive systems. Based on Moyle (2002) and Smith and Leicester (2016) growth rates, *O. mykiss* captured in Guadalupe Creek in 2020 were predominantly young-of-the-year, with some that had been through a second summer, and one fish that may have been it its third year. The abundance of young-of-the-year fish observed indicates that Guadalupe Creek had successful reproduction and summer rearing in 2019.

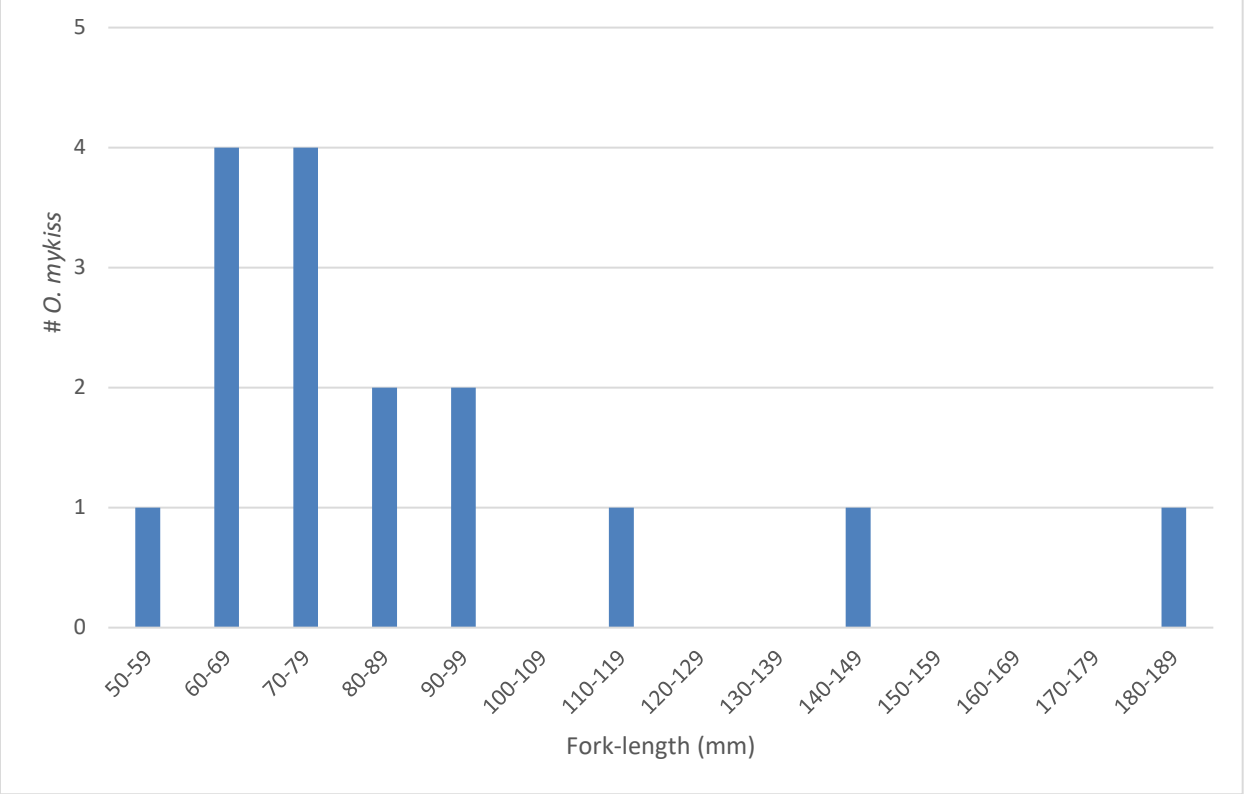


Figure 21. Guadalupe Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

The average *O. mykiss* density for all monitoring stations in 2020 was 0.08 *O. mykiss*/m (based on the number of fish caught (n)). The number of *O. mykiss* observed in 2020 was lower than the average densities observed in 2004 to 2019 at the four repeatedly sampled stations (0.17 *O. mykiss*/m). Based on the density of *O. mykiss* at each station, juvenile rearing appears to occur throughout Guadalupe Creek. In both 2019 and 2020 the highest densities were observed in the middle to the upstream end of the system (station GC004 and GC005).

Of the 16 *O. mykiss* encountered during the sampling efforts, five had a *Neascus*-type parasitic infection, commonly called “black spot” disease, caused by digenean trematodes in the families Diplostomatidae and Heterophyidae. The visible black spots associated with fish are the metacercaria stage of the free-swimming parasite that produce a melanin-induced fibrous cyst (Schaaf et al. 2017). None of the fish observed were classified with a severe infection (defined by Valley Water as raised cysts present on greater than 25% of the body, based on an ocular estimate). All infected fish were recorded with a low infection rate with raised cysts on less than 10% of the body. The impacts to *O. mykiss* associated with this infection are not known.

When Guadalupe Creek data from 2004 to 2019 is considered, the results indicate that *O. mykiss* production is variable, and the species is resilient. Guadalupe Creek is clearly important for production of *O. mykiss* in the larger Guadalupe River Watershed and supports an abundance of other native fish as well. Even with the low flow conditions present during the sampling in 2020, *O. mykiss* were still able to persist in the system, albeit in reduced numbers.

3.3 Los Gatos Creek

Sampling occurred on Los Gatos Creek on November 12 and 19, 2020. All sampling days were sunny and clear. Flows on Los Gatos Creek, based on ALERT gage 5050 – Los Gatos Creek at Lincoln Avenue, were approximately 4.9 cfs on November 12 and 7.8 cfs on November 19.

LG001

LG001 was the most downstream station sampled on Los Gatos Creek. This station was moved downstream in 2019 from the site previously sampled in 2018. The 2020 station location remained consistent with the 2019 location. The station is bordered by urban development including a city park, and there were numerous homeless encampments and other signs of human disturbance present during sampling. The monitoring station was 40.0 m in length with an average wetted width of 6.0 m and an average depth of 0.8 m. Three habitat types were present within the station: riffle, glide, and pool (Figure 22). The habitat consisted of 80% glide, 17% riffle, and 3% pool. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 20. A concrete wall lined a portion of the east bank, contributing to artificial structure in the channel.

Four species of fish were captured during the survey: California roach, bigscale logperch (*Percina macrolepida*), inland silverside (*Menidia beryllina*), and channel catfish (*Ictalurus punctatus*). California roach are a native species; the rest are non-native. The most abundant species encountered was California roach (n=25) and the MLIP indicates the number of California roach, as well as inland silverside, present is likely higher than what was encountered. While The habitat present could potentially support rearing of *O. mykiss*, none were captured. Fish captured and associated population estimates are summarized in Table 21.



Figure 22. Photos of station LG001, looking upstream (left) and looking downstream (right).

Table 20. LG001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
580.00	14.23	10.04	10.40			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	1	3	2	1	1	2

Table 21. Number captured and population estimates at station LG001.

Species	Native	n	N	SE	95% CI
Bigscale logperch	No	1	1	0.00	1-1
California roach	Yes	25	35	11.99	25-59
Channel catfish	No	1	1	0.73	1-1
Inland silverside	No	2	2	1.04	2-15

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Station LG001 had predicted capture rates for California roach higher than what was observed.

LG003

LG003 is bordered by residential development. Trash and other impacts associated with homeless encampments and anthropogenic uses were prevalent in the area surrounding this station. The monitoring station was reduced to 24.0 m in length due to the presence of a homeless encampment at the upstream end of the station posing health and safety concerns. The average wetted width was 3.0 m and the average depth was 0.4 m. Two habitat types were present within the station: riffle and run (Figure 23). The riffle habitat made up 21% with the run habitat making up the remaining 79%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 22.



Figure 23. Photos of station LG003, looking upstream (left) and looking downstream (right).

Table 22. LG003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
445.00	13.22	12.23	6.90

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	3	1	1	2	0	0

No fish were captured during the first two passes, so a third pass was not conducted at this station.

LG004

LG004 is the most upstream station and it is situated amongst commercial development. This site was the location of the Valley Water Stream Maintenance Program's Los Gatos Creek Instream Habitat Complexity Project. This project consisted of large woody debris implementation and gravel augmentation. The project was completed in the month prior to the sampling event in 2019. The monitoring station was 38.0 m in length with an average wetted width of 8.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and run (Figure 24). The riffle habitat made up 32% and the run the remaining 68%. The primary substrate was cobble with a secondary substrate of silt. Most of the cobble in the reach and the large woody debris present was part of the restoration project. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 23.

Two species of fish were captured during the survey: Sacramento sucker and largemouth bass. Sacramento sucker was the most abundant species encountered (n=10), and the MLIP estimate was higher than what was captured for both species. No *O. mykiss* were captured at this monitoring station.



Figure 24. Photos of station LG004, looking upstream (left) and looking downstream (right).

Table 23. LG004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
436.00	14.76	10.45	7.0			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	1	3	3	2	2	2

Table 24. Number captured and population estimates at station LG004.

Species	Native	n	N	SE	95% CI
Largemouth bass	No	2	2	0.38	2-7
Sacramento sucker	Yes	10	15	0.00	15-15

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

Los Gatos Creek Discussion

Juvenile rearing sampling on Los Gatos Creek began in 2018. No *O. mykiss* were collected in the Los Gatos Creek sub-watershed in 2018, 2019, or 2020, although all stations had some suitable habitat complexity (e.g., undercut banks, large woody debris, submerged roots, etc.) that could be used as refugia and had riffle habitat that should support fast-water feeding requirements. *O. mykiss* have been known to occur in the system, at least periodically, as they have been observed by others. For example, Hobbs et al. (2014) sampled Los Gatos Creek in January and February 2014 and captured a total of nine *O. mykiss* at two stations, but captured none in October 2014 at a monitoring station near Bascom Avenue (Hobbs 2015). There have been no other anecdotal reports of *O. mykiss* since 2014. It is likely that *O. mykiss* production is not high in this system, and/or Los Gatos Creek could still be recovering from drought conditions.

Los Gatos Creek had a relatively low abundance of fish, with one of the three stations having no fish of any species captured. A better understanding of occurrence and

trends of fish populations are expected to develop over time as additional juvenile rearing data is collected in future years. Currently, Los Gatos Creek has a higher richness of non-native species compared with other systems in the Guadalupe River Watershed, although suitable habitat to support native fishes appears to be present in the Los Gatos Creek sub-watershed.

3.4 Alamitos Creek

Sampling occurred at five stations on Alamitos Creek on November 9, 10, and 12, 2020. The weather was sunny and clear with no precipitation. Flows at the two most upstream stations (AC004 and AC003), based on ALERT gage 1544 Alamitos Creek below Almaden Reservoir, were approximately 2.8 to 3.3 cfs. Flows at the three most downstream stations (AC001, AC002, and ACBONUS), which are downstream of the confluence with Calero Creek, were 13.4 to 14.4 cfs, based on ALERT gage 5070 Alamitos Creek at Greystone.

AC001

This was the second most downstream station sampled on Alamitos Creek in 2020. The station is situated in an urban residential area with a walking trail along the west bank. The monitoring station was 40.0 m in length with an average wetted width of 4.0 m and an average depth of 0.3 m. Two habitat types were present within the station: riffle and run (Figure 25). The riffle habitat made up 25% of the habitat and the run the remaining 75%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 25.



Figure 25. Photos of station AC001, looking upstream (left) and looking downstream (right).

Table 25. Station AC001 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
509.00	11.85	11.73	15.50			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	1	1	2	2	2	0

Four species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, and Sacramento sucker. The most abundant species encountered was prickly sculpin (n=25). Four *O. mykiss* were captured and PIT-tagged at this station. Fish captured and associated population estimates are summarized in Table 26. The MLIP provided population estimates higher than what was observed for prickly sculpin.

Table 26. Number captured and population estimates at station AC001.

Species	Native	n	N	SE	95% CI
California roach	Yes	18	18	0.65	18-19
Prickly sculpin	Yes	25	27	2.96	25-33
O. mykiss	Yes	4	4	1.47	4-9
Sacramento sucker	Yes	5	5	0.17	5-5

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

A more detailed analysis of results of the *O. mykiss* capture data is provided in the "Alamitos Creek Discussion" later in this document.

AC002

The station is situated in an urban residential area with a walking trail along the south bank. The monitoring station was 30.0 m in length with an average wetted width of 4.0 m and an average depth of 0.5 m. Three habitat types were present within the station: riffle, run, and glide (Figure 26). The riffle habitat made up 33% of the habitat, the run 17%, and the glide the remaining 50%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 27.



Figure 26. Photos of station AC002, looking upstream (left) and looking downstream (right).

Table 27. AC002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
526.00	11.52	10.19	22.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	2	1	3	2	3	0

Five species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, Sacramento sucker, and tule perch (*Hysterocarpus traskii*). The most abundant species encountered was Sacramento sucker (n=7). Four *O. mykiss* were captured and PIT-tagged at this station. Fish captured and associated population estimates are summarized in Table 28.

Table 28. Number captured and population estimates at station AC002.

Species	Native	n	N	SE	95% CI
California roach	Yes	6	6	0.38	6-7
Prickly sculpin	Yes	4	4	0.21	4-5
O. mykiss	Yes	4	4	1.47	4-9
Sacramento sucker	Yes	7	8	2.99	7-15
Tule perch[2]	No	1	1	2.03	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

At station AC002 the MLIP provided population estimates higher than what was observed for Sacramento sucker. A more detailed analysis of *O. mykiss* capture data is provided in the "Alamitos Creek Discussion" section later in this document. All fish species captured were native except for tule perch. Tule perch are native to California and were observed in the Coyote Creek Watershed as far back as 1922 (Hubbs 1925). This species was thought to be extirpated in Santa Clara County until 1999 when a single specimen was captured in Coyote Creek (Valley Water 2015). Tule perch do not show up in historic records for the Guadalupe Watershed, but are now established in Calero Reservoir (Valley Water 2017). It is assumed that the reservoir is the source for the population in Alamitos Creek. Though the species is regionally native, it was likely not present in the Guadalupe Watershed until introductions to Calero Reservoir.

[2] Tule perch are native to California and were historically observed in the Coyote Creek Watershed (Hubbs 1925); however, it was likely not historically present in the Guadalupe River Watershed. For this analysis the species is considered non-native but are not believed to be harmful to the ecosystem.

AC003

AC003 is located upstream of the Calero Creek confluence and is situated in an urban residential area. The west bank through half of the station has large boulders that were placed by an earlier bank protection project. The monitoring station was 51.4 m in length with an average wetted width of 2.0 m and an average depth of 0.2 m. The channel had a single braid with a vegetated island dividing the channel. Four habitat types were present within the station: riffle, step-run, run, and pool (Figure 27). The riffle habitat only made up 2%, the large boulders from the bank protection project created a step-run through 51%, the run made up 27%, and the pool the remaining 20% of the sampling area. The primary substrate was boulder with a secondary substrate of cobble. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 29.



Figure 27. Photos of station AC003, looking upstream (left) and looking downstream (right).

Table 29. AC003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
436.00	10.34	12.13	36.80

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	3	1	1	2	1	3

Three species of fish were captured during the survey: *O. mykiss*, California roach, and Sacramento sucker. The most abundant species encountered was California roach (n=83). All fish encountered were native. Seven *O. mykiss* were captured, six of which were PIT-tagged at this station. The seventh fish was a recaptured fish that was tagged at AC003 on October 31, 2019. This fish measured 215 mm in fork length which was a growth of 98 mm from the 117 mm fork-length recorded at the time of initial capture on October 31, 2019. Fish captured and associated population estimates are summarized in Table 30.

Table 30. Number captured and population estimates at station AC003.

Species	Native	n	N	SE	95% CI
California roach	Yes	83	111	17.31	83-145
O. mykiss	Yes	7	7	0.58	7-8
Sacramento sucker	Yes	54	71	13.05	54-97

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC003 the MLIP provided population estimates higher than what was observed for California roach and Sacramento sucker. A more detailed analysis of *O. mykiss* capture data is provided in the “Alamitos Creek Discussion” section later in this document.

AC004

AC004 is the most upstream station on Alamitos Creek. Portions of the station were underneath the Almaden Way bridge (that connects Almaden and Bertram Roads). The bridge footing extended into the channel. The monitoring station was 40.0 m in length with an average wetted width of 3.5 m and an average depth of 0.3 m. Three habitat types were present within the station: riffle, run, and pool (Figure 28). The riffle habitat made up 50% of the sampling area, the run 32%, and the pool contributed the remaining 18%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 31.



Figure 28. Photos of station AC004, looking upstream (left) and looking downstream (right).

Table 31. AC004 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
430.00	11.55	10.13	8.30			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
1	2	0	1	3	1	1

Three species of fish were captured during the survey: *O. mykiss,* California roach, and prickly sculpin. All fish species captured were native. California roach were the most abundant species present (n=8). Of the six *O. mykiss* captured, five were ≥ 65 mm and were PIT-tagged prior to being released. Fish captured and associated population estimates are summarized in Table 43.

Table 32. Number captured and population estimates at station AC004.

Species	Native	n	N	SE	95% CI
California roach	Yes	8	8	1.06	8-10
Prickly sculpin	Yes	3	3	0.00	3-3
O. mykiss	Yes	6	6	0.67	6-8

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station AC004 the MLIP did not provide population estimates higher than what was observed for any of the species captured. A more detailed analysis of *O. mykiss* capture data is provided in the "Alamitos Creek Discussion" section later in this document.

ACBONUS

This station is targeted to increase the number of PIT tags in the system, and will move every year. In 2020, this station was located downstream of AC001. It is situated in an urban residential area. This site was at the location of the Valley Water Stream Maintenance Program's Alamitos Creek Instream Habitat Complexity Project. This project consisted of the implementation of a wood vortex weir, large woody debris and gravel augmentation. The monitoring station was 43.0 m in length with an average wetted width of 3.0 m and an average depth of 0.2 m. Two habitat types were present within the station: riffle and run (Figure 29). The riffle habitat made up 65% of the habitat and the run the remaining 35%. The primary substrate was cobble with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 33.



Figure 29. Photos of station ACBONUS, looking upstream (left) and looking downstream (right).

Table 33. ACBONUS water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
522.00	12.55	11.14	15.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
3	1	2	0	1	1	0

Three species of fish were captured during the survey: *O. mykiss,* California roach, and prickly sculpin. All fish species captured were native. Three *O. mykiss* were captured and PIT-tagged prior to being released. Fish captured and associated population estimates are summarized in Table 34.

Table 34. Number captured and population estimates at station ACBONUS.

Species	Native	n	N	SE	95% CI
California roach	Yes	3	5	9.68	3-32
Prickly sculpin	Yes	74	95	13.62	74-122
O. mykiss	Yes	3	5	9.68	3-32

In station ACBONUS the MLIP provided population estimates higher than what was captured for all three species. The predicted number of *O. mykiss* was five compared to the three captured. A more detailed analysis of *O. mykiss* capture data is provided in the "Alamitos Creek Discussion" section below.

Alamitos Creek Discussion

Twenty-four *O. mykiss* were collected from all five Alamitos Creek monitoring stations. The MLIP estimated the population of *O. mykiss* within the 2020 monitoring stations to be a total of 26 fish. The average standardized density of *O. mykiss* observed in Alamitos Creek in 2020 was 0.12 *O. mykiss*/m with an estimated density 0.13 *O. mykiss*/m. The average standardized density in 2019 was 0.25 *O. mykiss*/m and the average standardized density in 2018 in Alamitos Creek was 0.20 *O. mykiss*/m. While individual stations saw fluctuations in numbers observed from 2018 to 2020, there were fewer *O. mykiss* present on average in 2020 compared to the previous years (Figure 30).

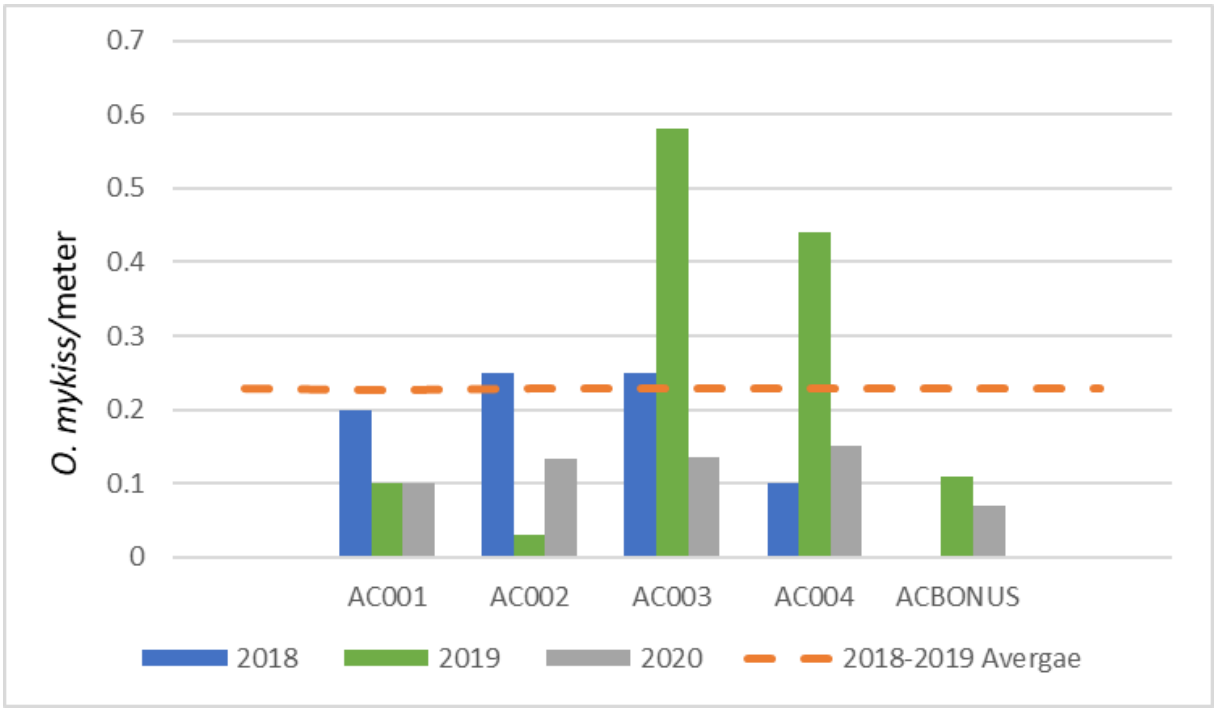


Figure 30. Capture densities of *O. mykiss* in 2018-2020 within all Alamitos Creek monitoring stations. ACBONUS *O. mykiss* densities between years cannot be compared since the station location changes each year.

O. mykiss fork-lengths ranged from 50 mm to 240 mm (Figure 31). Based on Moyle (2002) and Smith and Leicester (2016) growth rates, most *O. mykiss* captured were at the end of their second year, with young-of-the-year fish and *O. mykiss* potentially in their third year. Based on the results of the 2020 sampling, Alamitos Creek had successful reproduction and multiple age classes present. The presence of *O. mykiss* in the 50 to 59 mm size range indicates either late reproduction or growth rates slower than what was observed by Smith and Leicester (2016) and Moyle (2002). *O. mykiss* in this system continue to show signs of blackspot disease. Of the 24 captured, 23 had visible symptoms, with 10 fish recorded with a low severity infection (<10% raised cysts), 8 fish recorded with a moderate severity infection (10-25% of the body experiencing symptoms), and 5 recorded with a severe infection (greater than 25% of the body experiencing symptoms). In 2019, 28 of the 53 fish captured were recorded with low or moderate severity blackspot infections. This was a significant increase in the prevalence of blackspot disease compared with the fish captured on Alamitos Creek in 2019. Of all systems sampled, blackspot disease was most prevalent in Alamitos Creek *O. mykiss* in both 2019 and 2020 (blackspot disease severity was documented for the purposes of this report beginning in 2019).

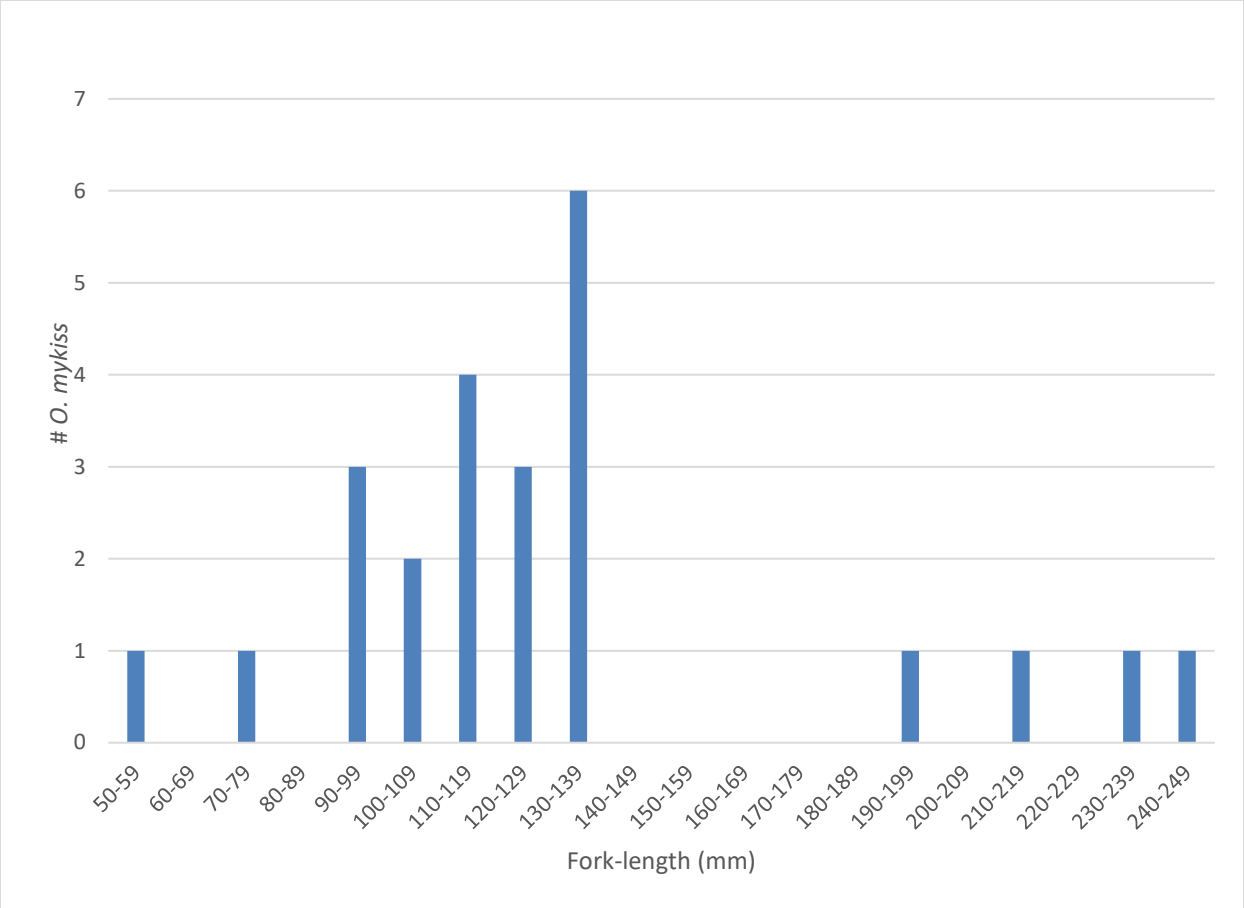


Figure 31. Alamitos Creek *O. my*kiss length histogram (2020). All measurements are in fork-length and binned in 10 mm increments.

Alamitos Creek is also supporting four other species of native fish and continues to show evidence of a small population of tule perch. This species was the only fish captured that is considered to be non-native, though it is considered native to other watersheds in Santa Clara County (e.g., Coyote Creek). Tule perch are not considered to be a predator of *O. mykiss*.

3.5 Calero Creek

Sampling occurred at three stations on Calero Creek on November 11, 2020. The weather was sunny and clear. Flows on Calero Creek based on ALERT gage 5013 - Calero Creek below Calero Reservoir were approximately 10.0 cfs during the sampling period.

CC001

CC001 was the most downstream station sampled on Calero Creek. The station is situated in an urban residential area and is approximately 300.0 m upstream of the confluence with Alamitos Creek. The monitoring station was 40.0 m in length with an average wetted width of 2.0 m and an average depth of 0.5 m. Two habitat types were present within the station: riffle and run (Figure 32). The run habitat made up 93% of the habitat with the riffle making up the remaining 7%. The primary substrate was silt with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 35.



Figure 32. Photos of station CC001, looking upstream (left) and looking downstream (right).

Table 35. CC001 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
519.00	17.45	8.33	41.7

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
4	0	1	1	3	1	1

Five species of fish were captured during the survey: *O. mykiss*, California roach, prickly sculpin, Sacramento sucker, and largemouth bass. The two *O. mykiss* captured at this station received PIT tags. Fish captured and associated population estimates are summarized in Table 36.

Table 36. Number captured and population estimates at station CC001.

Species	Native	n	N	SE	95% CI
California roach	Yes	10	11	2.43	10-16
Largemouth bass	No	1	1	2.03	1-1
Prickly sculpin	Yes	1	1	0.00	1-1
O. mykiss	Yes	2	2	0.00	2-2
Sacramento sucker	Yes	3	4	0.00	3-4

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC001 the MLIP provided population estimates higher than what was observed for California roach and Sacramento sucker. A more detailed analysis of *O. mykiss* capture data is provided in the “Calero Creek Discussion” section later in this document.

CC002

CC002 is situated in an urban residential area. A small sakrete structure at an outfall was present. The monitoring station was 40.0 m in length with an average wetted width of 2.5 m and an average depth of 0.4 m. Two habitat types were present within the station: riffle and run (Figure 33). The riffle habitat made up 20% of the habitat and the run made up 80%. The primary substrate was cobble with a secondary substrate of silt. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 37.



Figure 33. Photos of station CC002, looking upstream (left) and looking downstream (right).

Table 37. CC002 water quality data and ocular estimates of habitat complexity.

Water Quality						
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**			
505.00	15.86	10.62	35.00			
Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
0	1	0	1	3	1	1

Three species of fish were captured during the survey: *O. mykiss*, California roach, and Sacramento sucker. The most abundant species encountered was *O. mykiss* (n=18). Fifteen of the 18 *O. mykiss* captured were PIT-tagged at this station. Fish captured and associated population estimates are summarized in Table 38.

Table 38. Number captured and population estimates at station CC002.

Species	Native	n	N	SE	95% CI
California roach	Yes	10	20	25.04	10-73
O. mykiss	Yes	18	19	2.23	18-24
Sacramento sucker	Yes	4	4	1.47	4-9

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC002 the MLIP provided population estimates higher than what was observed for California roach and *O. mykiss*. All fish species captured were native. A more detailed analysis of *O. mykiss* capture data is provided in the “Calero Creek Discussion” section later in this document.

CC003

CC003 is situated in a rural/agricultural area. The monitoring station was 40.0 m in length with an average wetted width of 2.5 m and an average depth of 0.3 m. Two habitat types were present within the station: riffle and run (Figure 34). The run habitat made up 75% of the sampling area with the riffle making up the remaining 25%. The primary substrate was silt with a secondary substrate of gravel. Results of the water quality monitoring and the ocular assessment of habitat complexity are provided in Table 39.



Figure 34. Photos of station CC003, looking upstream (left) and looking downstream (right).

Table 39. CC003 water quality data and ocular estimates of habitat complexity.

Water Quality			
Conductivity (µS/cm)	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**Turbidity (NTU)**
498.00	15.15	9.13	37.00

Habitat Complexity Scoring						
Macrophytes/Emergent Vegetation	**Boulders**	**Woody Debris**	**Undercut Banks**	**Overhanging Vegetation**	**Roots**	**Artificial Structures**
2	0	1	1	3	1	0

Three species of fish were captured during the survey: *O. mykiss,* California roach, and Sacramento sucker. The most abundant species encountered was *O. mykiss* (n=15). Thirteen of the 15 *O. mykiss* captured at this station were PIT-tagged. Fish captured and associated population estimates are summarized in Table 40.

Table 40. Number captured and population estimates at station CC003.

Species	Native	n	N	SE	95% CI
California roach	Yes	10	11	2.43	10-16
O. mykiss	Yes	15	15	0.77	15-17
Sacramento sucker	Yes	1	1	0.00	1-1

n = total number captured, N = calculated population estimate, SE = standard error, CI = confidence interval

In station CC003 the MLIP provided population estimates higher than what was captured for California roach. A more detailed analysis of *O. mykiss* capture data is provided in the “Calero Creek Discussion” section below.

Calero Creek Discussion

A total of 35 *O. mykiss* were collected in all three monitoring stations sampled. The MLIP provided an *O. mykiss* density estimation higher than what was captured in 2020. The average standardized density of *O. mykiss* in Calero Creek in 2020 was 0.29 *O. mykiss*/m, which was an increase from 2019 when the average standardized density was 0.07 *O. mykiss*/m. The 2020 average standardized density was also more than double the density of what was captured in Calero Creek in 2018, which was 0.14 *O. mykiss*/m (Figure 35). The average density in Calero Creek in 2020 was higher than the

observed average density of repeated monitoring stations from 2004 to 2019 on Guadalupe Creek (0.17 *O. mykiss*/m) and the 2018-2019 data on Alamitos Creek (0.23 *O. mykiss*/m). Guadalupe Creek and Alamitos Creek are larger sub-watersheds (9,489 and 11,808 acres, respectively) with suitable habitat, so it is typically expected that they would support higher fish densities than Calero Creek (6,762 acres). Calero Creek plays an essential role in *O. mykiss* reproduction and is contributing to the overall production in the Guadalupe River Watershed. Blackspot disease was not observed on any of the *O. mykiss* in Calero Creek in 2020. This is a decrease in the prevalence of blackspot on Calero Creek from 2019, as there were two *O. mykiss* captured on Calero Creek with a low severity infection of blackspot in 2019.

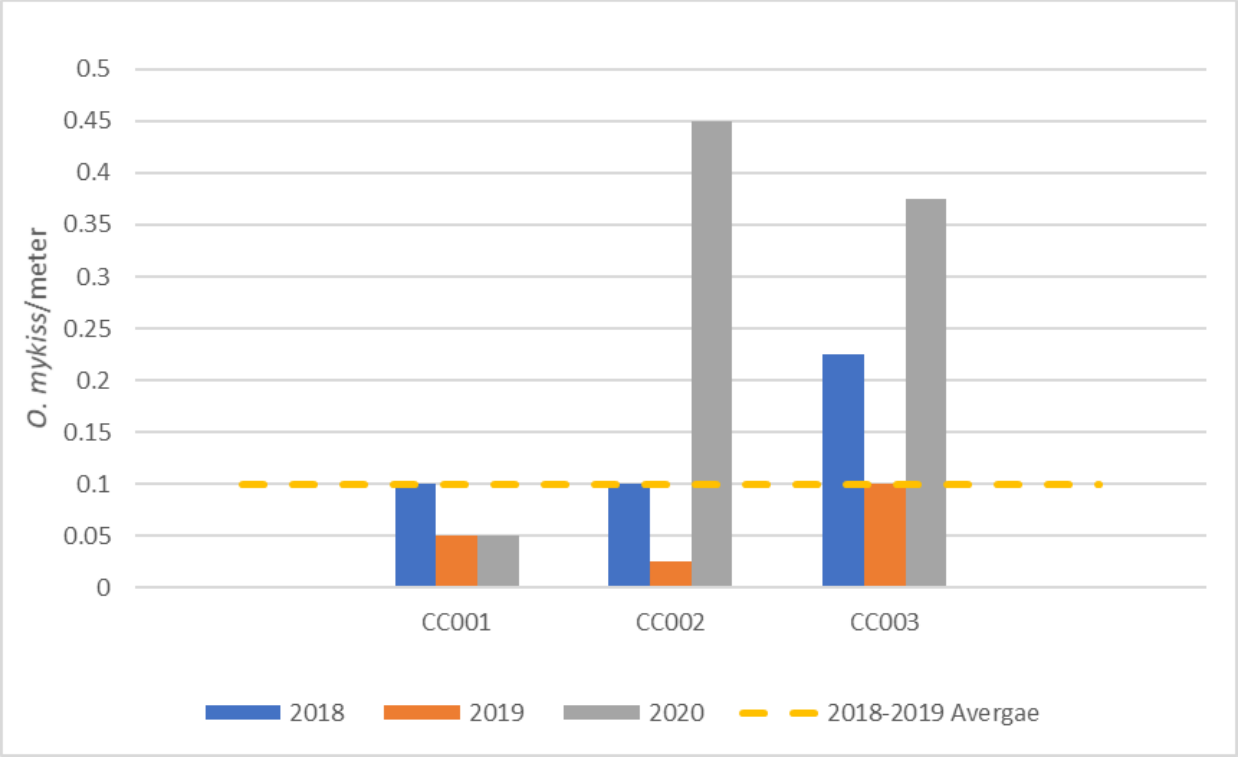


Figure 35. Capture densities of *O. mykiss* from 2018-2020 within all Calero Creek monitoring stations.

O. mykiss fork-lengths ranged from 55 mm to 290 mm (Figure 36). Based on Moyle (2002) growth rates, *O. mykiss* captured in Calero Creek in 2020 were mostly young-of-the-year, with the potential for some fish in their second year, and a single fish

potentially extending into its third year. Based on Smith and Leicester (2016) growth rates from Guadalupe Creek, all but one *O. mykiss* captured in 2020 were young-of-the-year, with the one fish likely in its third year. Therefore, Calero Creek supported at least two age classes of *O. mykiss*, with a potential of three (Figure 46). Based on the results of the 2020 sampling, Calero Creek supports rearing of *O. mykiss,* and had successful reproduction and summer rearing in 2019. Again, like in Alamitos Creek, the presence of *O. mykiss* less than 60 mm could indicate late reproduction in spring 2019, or slower growth rates.

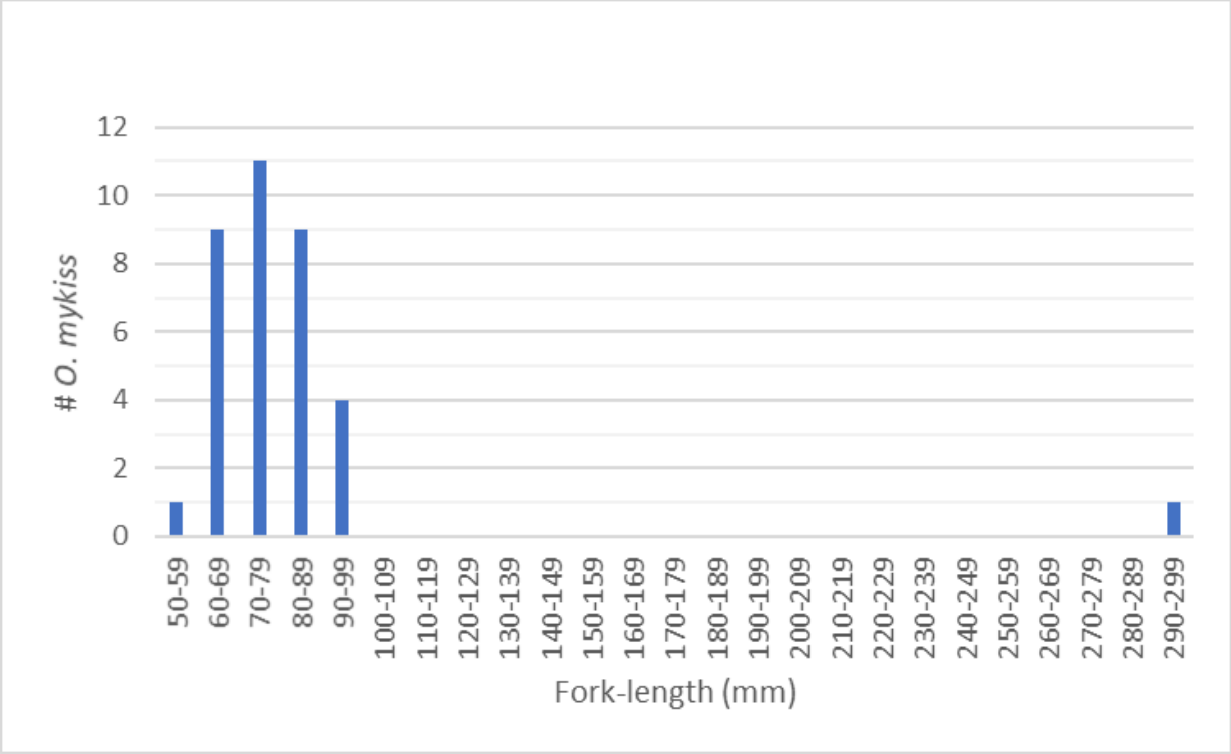


Figure 36. Calero Creek *O. mykiss* length histogram. All measurements are in fork-length and binned in 10 mm increments.

A total of four native species (*O. mykiss*, prickly sculpin, Sacramento sucker, and California roach) were detected during this sampling effort. A single non-native fish (largemouth bass) was encountered.

4. Conclusion

In the Guadalupe Watershed in 2020, juvenile *O. mykiss* were observed in Guadalupe Creek, Alamitos Creek, and Calero Creek. A total of 75 *O. mykiss* were captured during the monitoring effort, 63 of which were tagged with Passive Integrated Transponder (PIT) tags to study their movement within the Guadalupe River Watershed. They were not observed in Los Gatos Creek or Guadalupe River. It is unknown if it is normal for no detections to occur in Los Gatos Creek in some years, as this is only the third year of sampling this creek as part of this juvenile O. mykiss rearing monitoring effort. It is important to remember that electrofishing sampling only allows for specific habitats to be sampled. It is not feasible in deep pools, which may be the preferred habitat for *O. mykiss* inhabiting this system.

The average densities (*O. mykiss*/m) and median length of *O. mykiss* detected in Guadalupe, Alamitos, and Calero Creeks are provided in Table 41. Calero Creek had the highest densities, with Alamitos Creek supporting *O. mykiss* with the highest fork-lengths. Figure 37 shows the size distribution of all *O. mykiss* collected in the Guadalupe River Watershed. While Alamitos Creek is producing fish with the greatest fork-lengths, Guadalupe and Calero Creeks are supporting more young-of-the-year sized fish. Based on the size range of fish collected, production and successful summer rearing occurred and multiple age classes were present in Alamitos, Calero, and Guadalupe Creeks in 2020. It is likely no reproduction is occurring in the Guadalupe River and fish are only using it for rearing and staging prior to outmigration.

Table 41. 2020 average density and median fork-length of *O. mykiss* captured within Alamitos, Calero, and Guadalupe Creeks.

Sub-Watershed	*O. mykiss*/m	Median fork-length (mm)
Guadalupe Creek	0.08	77
Alamitos Creek	0.12	124
Calero Creek	0.29	74

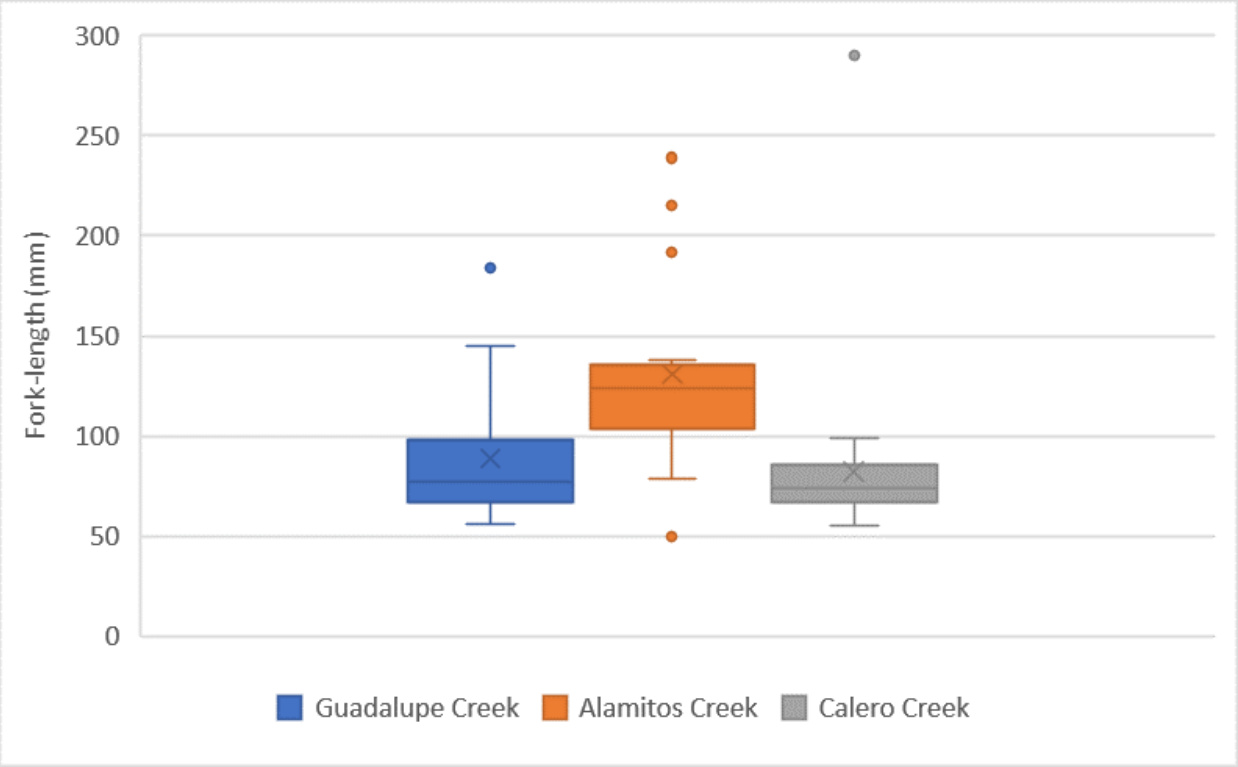


Figure 37. Box plot of *O. mykiss* size distribution (fork-length) for Alamitos, Calero, and Guadalupe Creek sub-watersheds. The box displays the first and third quartiles, the median (line within the box), mean (x symbol), with whiskers indicating the highest and lowest points within 1.5 times the interquartile range, and outlier points that fall outside the 1.5 times the interquartile range.

In addition to *O. mykiss* data, information on species composition in the Guadalupe River Watershed, including the presence of non-native fish species, was obtained. No non-native species were collected in Guadalupe Creek. A single largemouth bass was observed in Calero Creek. A single tule perch, which are considered non-native as they were not known to occur in the Guadalupe Watershed historically, was observed in Alamitos Creek, but they are not a predator of *O. mykiss*. Four non-native species were collected in both Los Gatos Creek and Guadalupe River, including largemouth bass, which are considered to be major predators of juvenile *O. mykiss*. However, all non-native species can impact the habitat and natural communities within the system. Guadalupe River had the highest percentage of non-native species detected, with over 16% of captured fish being non-native. Over 14% of fish captured in Los Gatos Creek

were non-native. Looking at the Guadalupe River Watershed as a whole, the overall percentage of non-native fish is less than 2% of all fish observed (Table 42).

Table 42. Total capture of fish per sub-watershed and percentage of total capture that was non-native species.

Sub-watershed	Guadalupe River	Guadalupe Creek	Los Gatos Creek	Alamitos Creek	Calero Creek	Guadalupe Watershed
Total Fish Captured	36	329	41	315	75	796
Non-native Fish Captured	6	0	6	1	1	14
Percent Non-native	16.67%	0.00%	14.63%	0.32%	1.33%	1.76%

Juvenile *O. mykiss* are persisting in the Guadalupe River Watershed, with multiple age classes present. Non-native fish are contributing to a small percentage of the total abundance, with minimal detections in the upper watershed. Since this is only the third year of expanded monitoring it is difficult to assess any trends at this time, but as more data becomes available in the following years a better understanding of fish in the Guadalupe River Watershed will develop.

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Appendix A

2019-2020 Guadalupe River Watershed Stream Temperature Monitoring

2019-2020

Guadalupe River Watershed Stream Temperature Monitoring

Prepared By:

Valley Water

Environmental Mitigation and Monitoring Unit

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February 2021

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Introduction

The 440 square kilometer Guadalupe River Watershed begins in headwater tributaries near the summits of Loma Prieta and Mount Umunhum in the Santa Cruz Mountains then flows north into the mainstem of the Guadalupe River before draining into South San Francisco Bay through Alviso Slough. These upper watershed areas are developed to lesser extent with a lower degree of anthropogenic disturbance. The northern and eastern portions of the watershed are comprised of the Santa Clara County valley floor. Portions of the valley floor are extensively urbanized with patches of undeveloped parks and open agricultural lands. Major tributaries in the Guadalupe River Watershed include Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek.

The Guadalupe River Watershed supports the federally threatened Central California Coast steelhead (*Oncorhynchus mykiss, O. mykiss*) distinct population segment in 5 of its systems: Guadalupe River, Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek. Furthermore, there is designated critical habitat in the portion of the Guadalupe River between its confluence with San Francisco Bay and West Hedding Street in San Jose (70 FR 52570, September 2005).

Stream temperature is an important factor affecting the abundance and distribution of *O. mykiss.* To provide continuous monitoring of temperature conditions and help assess *O. mykiss* habitat suitability within the Guadalupe River Watershed, Valley Water conducts year-round temperature monitoring throughout the Guadalupe River, Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek. This report summarizes the stream temperature data collected in these systems for Water Year 2020 (Oct. 1, 2019−Sept. 30, 2020).

Methods

Monitoring Stations

Stream temperatures were monitored at twenty-four points of interest (POI) on *O. mykiss* streams throughout the Guadalupe River Watershed (Figure 1). These stations

were selected as they are within areas where *O. mykiss* migration, spawning, and/or rearing is expected to occur. Station locations are subject to change and additional stations may be established as monitoring efforts continue and management objectives are modified.

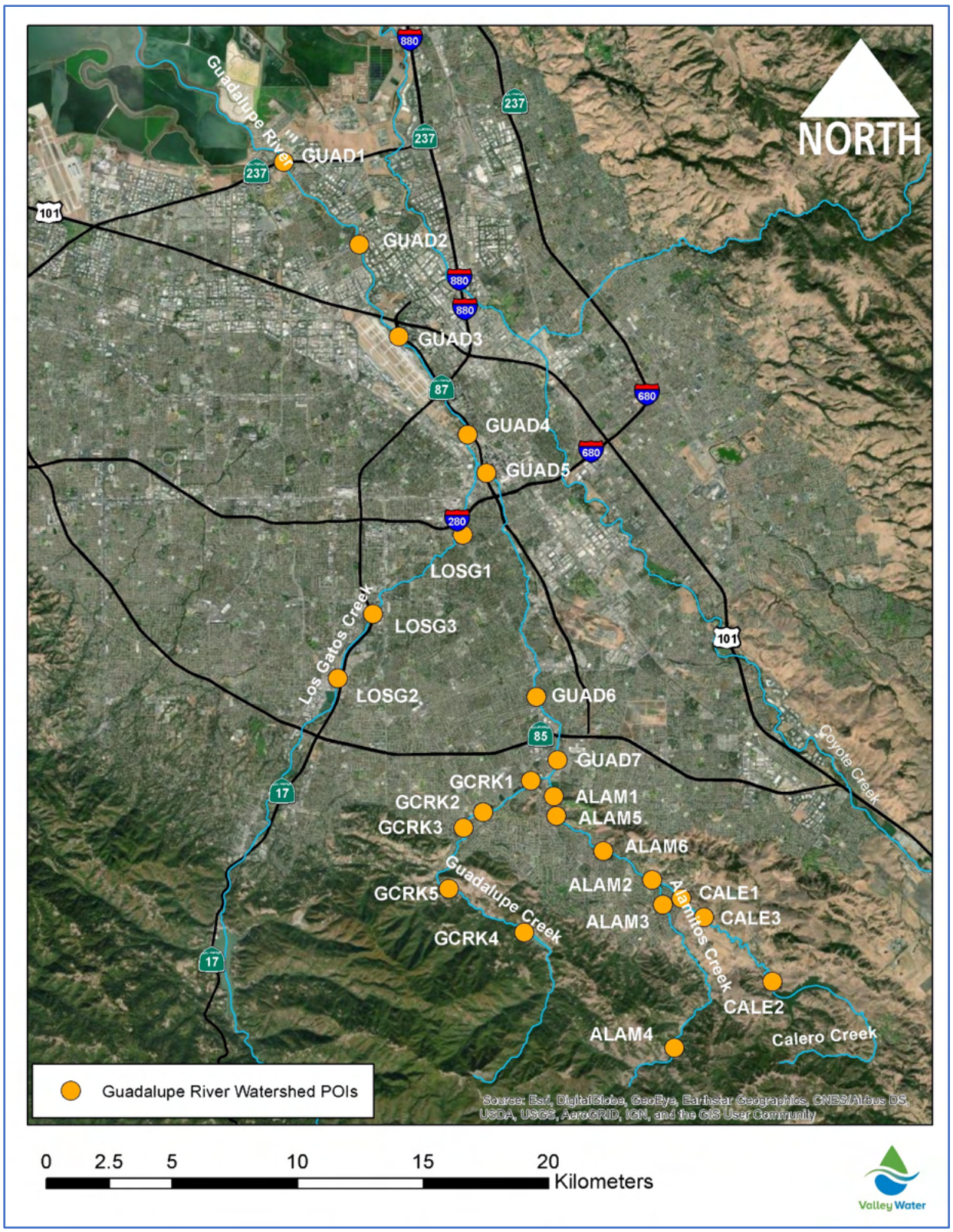


Figure 1. Guadalupe River Watershed stream temperature monitoring stations.

Temperature Loggers

Temperatures were recorded using Bluetooth-capable Onset HOBO® MX2203 Tidbit Temperature Loggers (herein referred to as logger(s)) (Figure 2). The loggers measured 4.45 x 7.32 x 3.58 cm, weighed 36.2 g, and had an accuracy of ±0.25°C with a resolution of 0.01°C. Using the Onset HOBO® mobile application from a smartphone, each logger was programmed to collect data at a 1-hour sampling rate and to start recording on the hour interval (e.g., 1:00PM, 2:00PM) following the deployment time.

Each logger was housed in an 11.5 cm x 4.3 cm galvanized steel pipe fitted with a cap at each end (Figure 3). The pipe had four 1.5 cm-diameter holes on the sides and a single hole on each of the caps to allow water to flow through the housing. In addition to providing protection and to shield the loggers from direct sunlight, the housing was also used to weigh down the logger, which helped ensure that it maintained contact with the streambed and thus remained submerged.



Figure 2. Onset HOBO® MX2203 Tidbit temperature logger.



Figure 3. Galvanized steel pipe housing for temperature loggers.

Logger Deployment

The housings (with logger inside) were attached using wire clips to a steel cable that was anchored to a stake or natural feature (e.g., tree trunk, root) along the bank of the channel. Loggers were placed in pools whenever possible to help ensure that they would stay submerged during summer low flows. One logger was deployed at each monitoring station.

Data Download and Analysis

The temperature data was downloaded in the field onto a smartphone using the Onset HOBO® mobile application. Once downloaded, data was transferred to the internal Valley Water network and visually inspected for any erroneous temperature readings that may have resulted from either logger malfunction or the logger not being submerged in water. The loggers also had a water detection capability that recorded when the logger was “in” versus “out” of the water. This function was useful during the initial data evaluation to help differentiate between water temperature and air temperature recordings. Anomalous data was clipped from the dataset before further analysis.

Temperature data was analyzed for Water Year 2020 (Oct. 1, 2019−Sept. 30, 2020). Guadalupe River loggers had obtainable data for the entire Water Year; however, loggers in the remaining systems were deployed after Oct. 1, 2019 and/or downloaded before Sept. 30, 2020. In those cases, stream temperature was analyzed for the time

period in which data was available within the Water Year. For each monitoring station, daily averages, minimums, and maximums were calculated, as well as the 7-day moving average to smooth out daily fluctuations and highlight trends. The 7-day moving average was calculated for each day as the average stream temperature observed for the last 7 days (that day plus the 6 consecutive prior days). In addition, maximum weekly average temperature (MWAT) was determined for each station and computed as the maximum value of the 7-day moving average of daily mean stream temperature.

Release rates from Guadalupe, Almaden, and Calero Reservoirs during Water Year 2020 stream temperature monitoring were retrieved from the Valley Water Surface Data Portal (Table 1). This information was considered when interpreting the results of the temperature data analysis for their respective creeks.

Table 1. Flow releases from Guadalupe, Almaden, and Calero Reservoirs during Water Year 2020 stream temperature monitoring[1].

Reservoir	Receiving Creek	Temp. Monitoring Period	Release Rate (cfs)
Guadalupe	Guadalupe Creek	Oct. 1, 2019 – Sept. 22, 2020	0.8 – 36.5
Almaden	Alamitos Creek	Oct. 1, 2019 – Sept. 21, 2020	1.2 – 150[2]
Calero	Calero Creek	Oct. 1, 2019 – Sept. 21, 2020	2.4 – 26.6

[1]Flow data was retrieved from the following stream gages: 5017=Guadalupe Creek below Guadalupe Reservoir; 5016=Alamitos Creek below Almaden Reservoir; 5013=Calero Creek below Calero Reservoir

[2]Releases increased to 45.4−150 cfs between April 5, 4:15PM and April 7, 7:00AM due to a rain event.

Results and Discussion

The following section summarizes the temperature monitoring results by system and includes a brief discussion for each. Results are presented in order from most downstream station to most upstream station.

Guadalupe River

GUAD1

Station GUAD1 is the most downstream monitoring station on the Guadalupe River located approximately 0.5 mi upstream of Salt Pond A8 under Highway 237 in Alviso. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 4. In Water Year 2020, stream temperatures ranged from 9.9 to 27.6°C with an average daily fluctuation of 2.9°C. The MWAT for station GUAD1 during the monitoring period was 24.8°C.

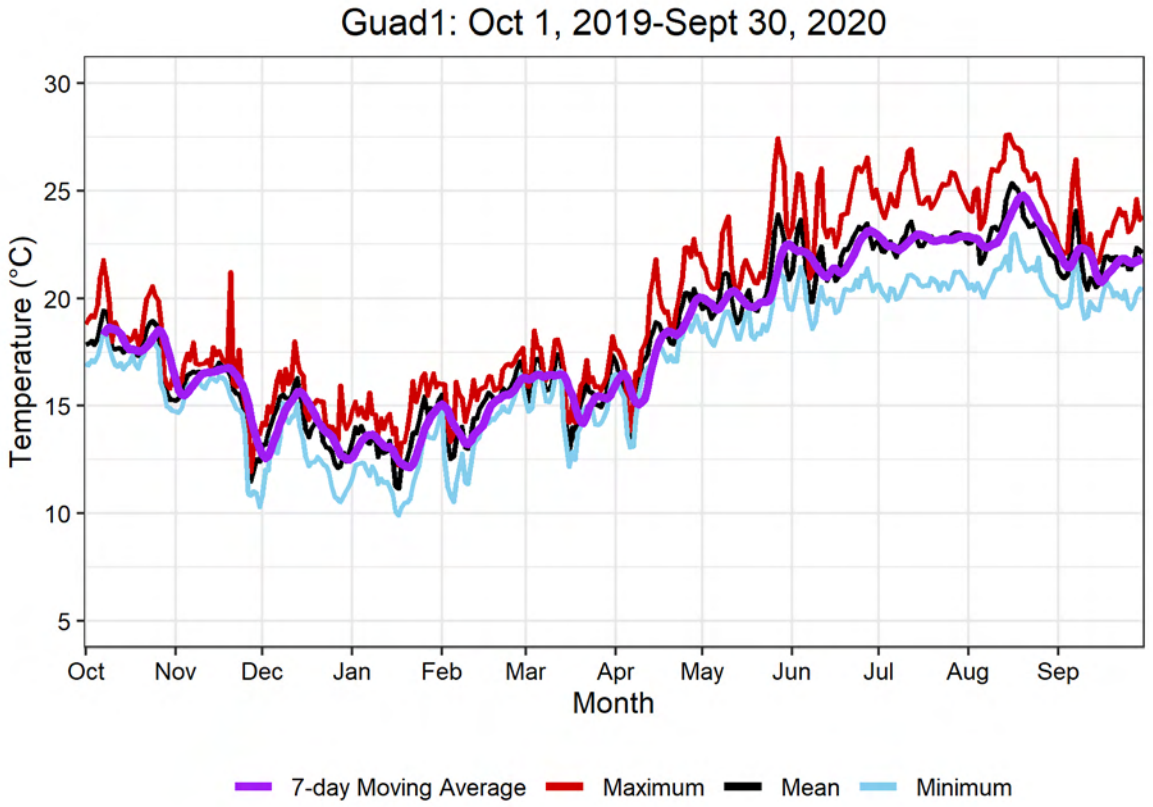


Figure 4. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD1.

GUAD2

Station GUAD2 is located upstream of GUAD1 and approximately 100 ft downstream of Montague Expressway in North San Jose. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 5. In Water Year 2020, stream temperatures ranged from 10.2 to 24.0°C with an average daily fluctuation of 1.6°C. The MWAT for station GUAD2 during the monitoring period was 22.2°C.

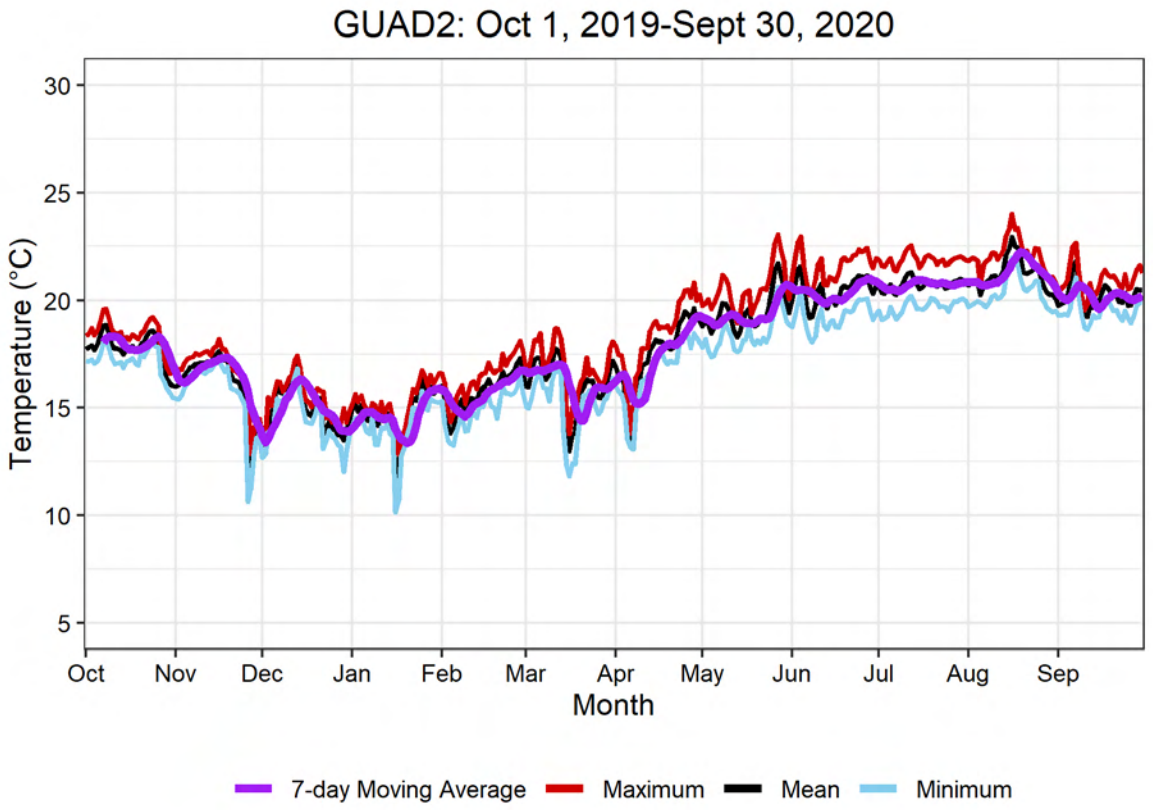


Figure 5. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD2.

GUAD3

Station GUAD3 is located upstream of GUAD2 and approximately 75 ft upstream of Airport Parkway in San Jose. This station is roughly 2,000 ft downstream of 2020 *O.*

mykiss juvenile rearing monitoring site GRBONUS (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 6. In Water Year 2020, stream temperatures ranged from 10.1 to 23.1°C with an average daily fluctuation of 1.3°C. The MWAT for station GUAD3 during the monitoring period was 21.8°C.

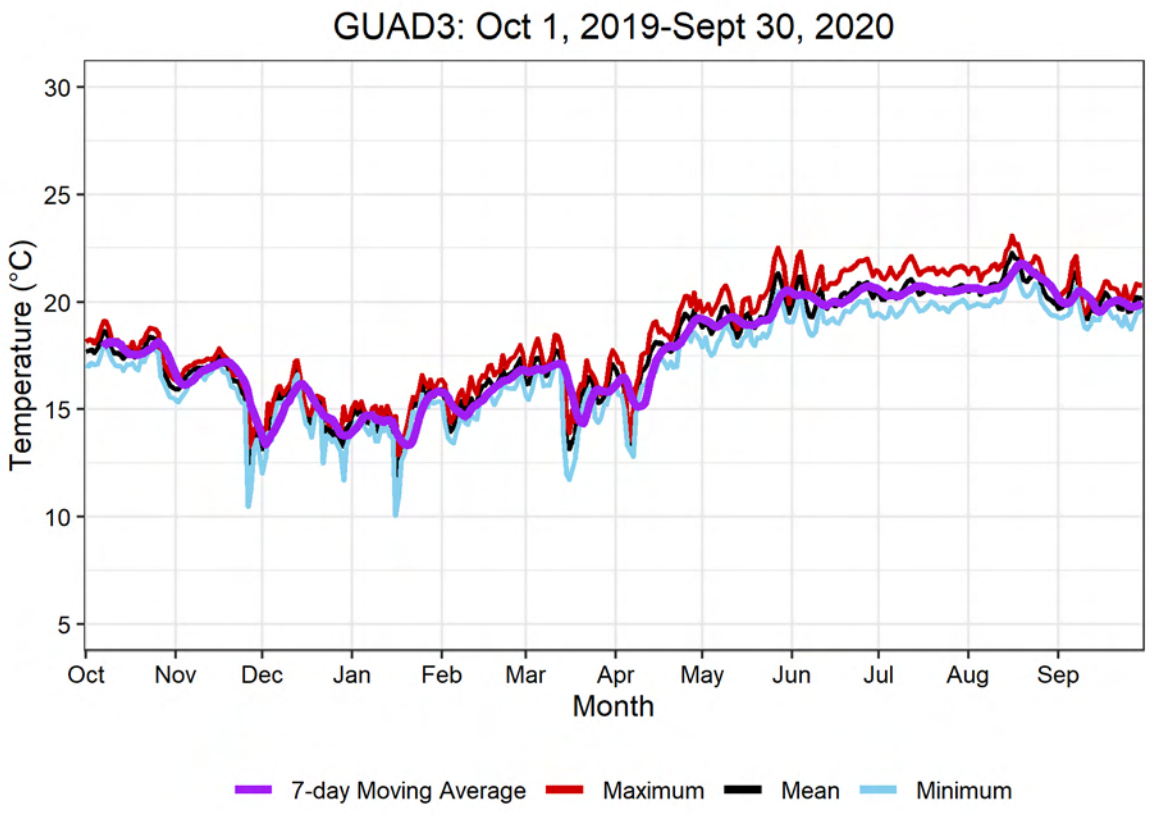


Figure 6. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD3.

GUAD4

Station GUAD4 is located upstream of GUAD3 and approximately 100 ft downstream of Coleman Avenue in San Jose. This station is roughly 200 ft upstream of *O. mykiss* juvenile rearing monitoring site GR002 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 7. In Water Year 2020, stream temperatures ranged from 10.5 to

29.3°C with an average daily fluctuation of 2.9°C. The MWAT for station GUAD4 during the monitoring period was 22.4°C.

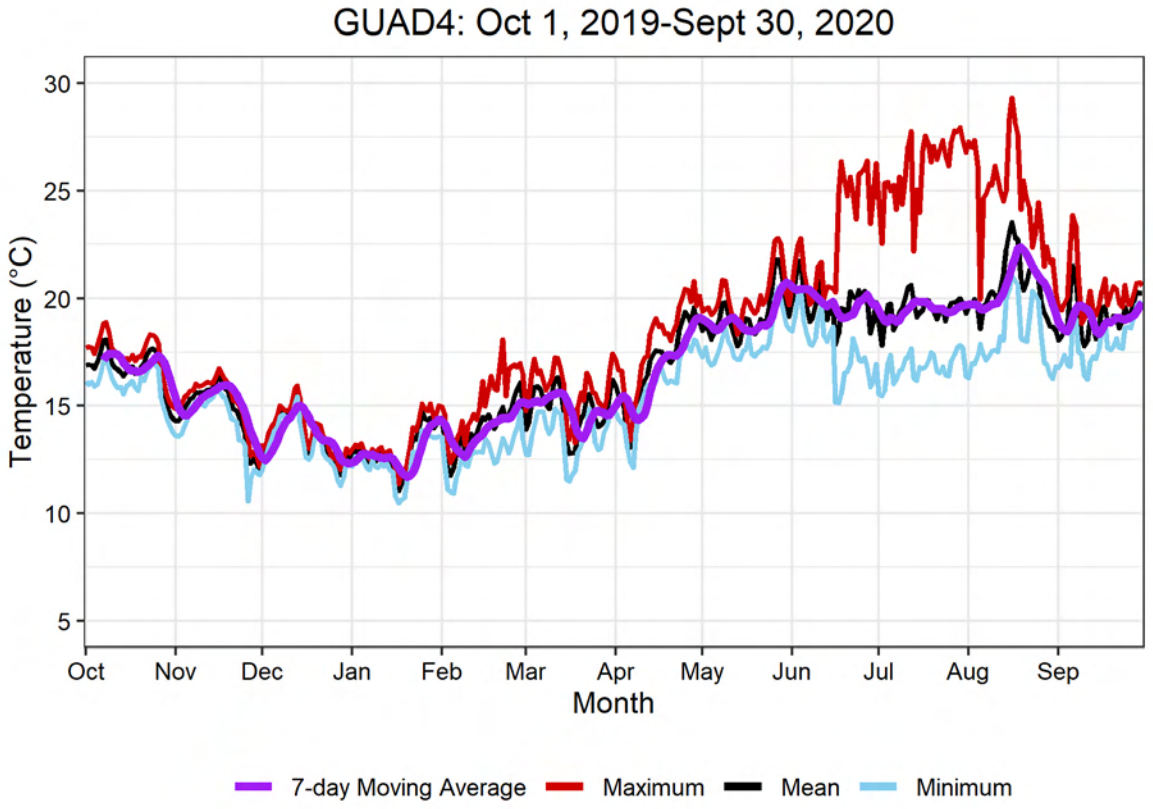


Figure 7. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD4.

GUAD5

Station GUAD5 is located upstream of GUAD4 and approximately 200 ft downstream of West Santa Clara Street in downtown San Jose. This station is roughly 700 ft upstream of *O. mykiss* juvenile rearing monitoring site GR003 (see Valley Water 2021a). The temperature logger at monitoring station GUAD5 was missing at the time of data retrieval (presumably lost or stolen); therefore, no data is available for Water Year 2020. A new logger was deployed at this location on Jan. 4, 2021 with the aim of collecting temperature data for the majority of Water Year 2021.

GUAD6

Station GUAD6 is located upstream of GUAD5 and approximately 1,000 ft downstream of Branham Lane in San Jose. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 8. In Water Year 2020, stream temperatures ranged from 8.9 to 28.7°C with an average daily fluctuation of 2.4°C. The MWAT for station GUAD6 during the monitoring period was 26.0°C.

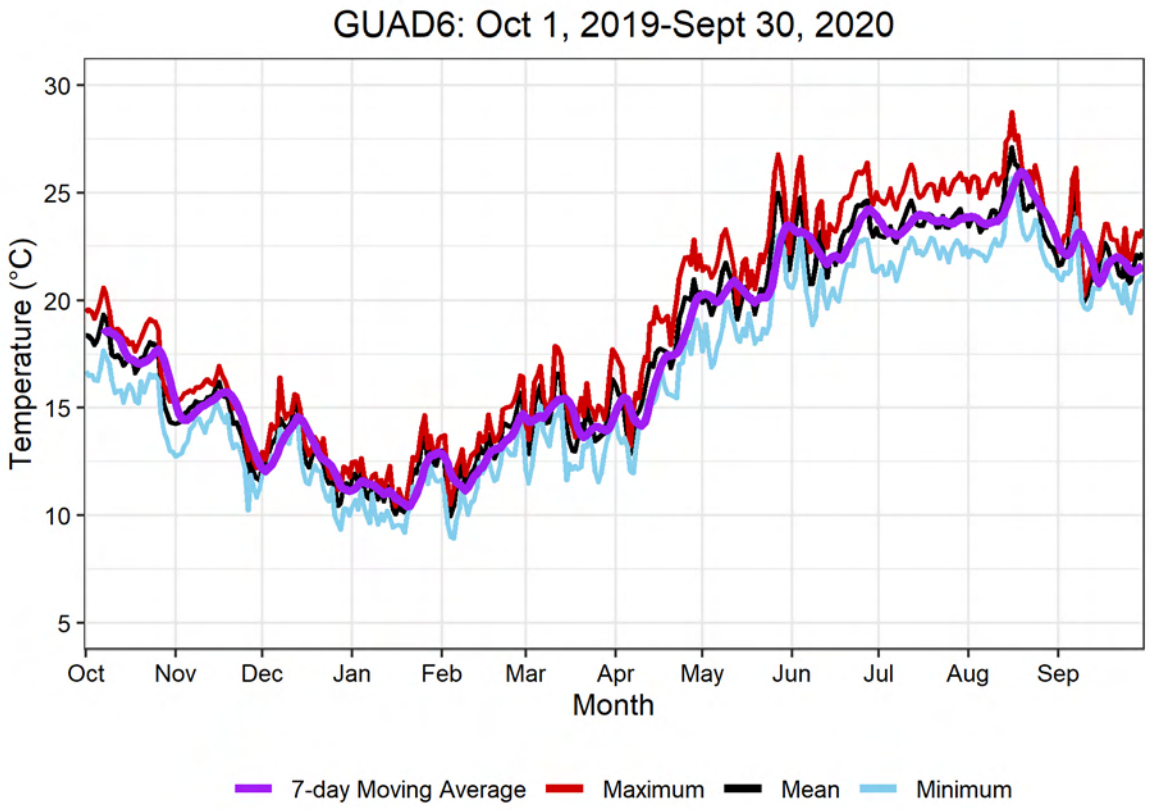


Figure 8. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD6.

GUAD7

Station GUAD7 is the most upstream monitoring station and is located approximately 200 ft upstream of Blossom Hill Road and 0.5 mi downstream of Almaden Lake in San

Jose. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 9. In Water Year 2020, stream temperatures ranged from 9.8 to 29.8°C with an average daily fluctuation of 3.0°C. The MWAT for station GUAD7 during the monitoring period was 26.1°C.

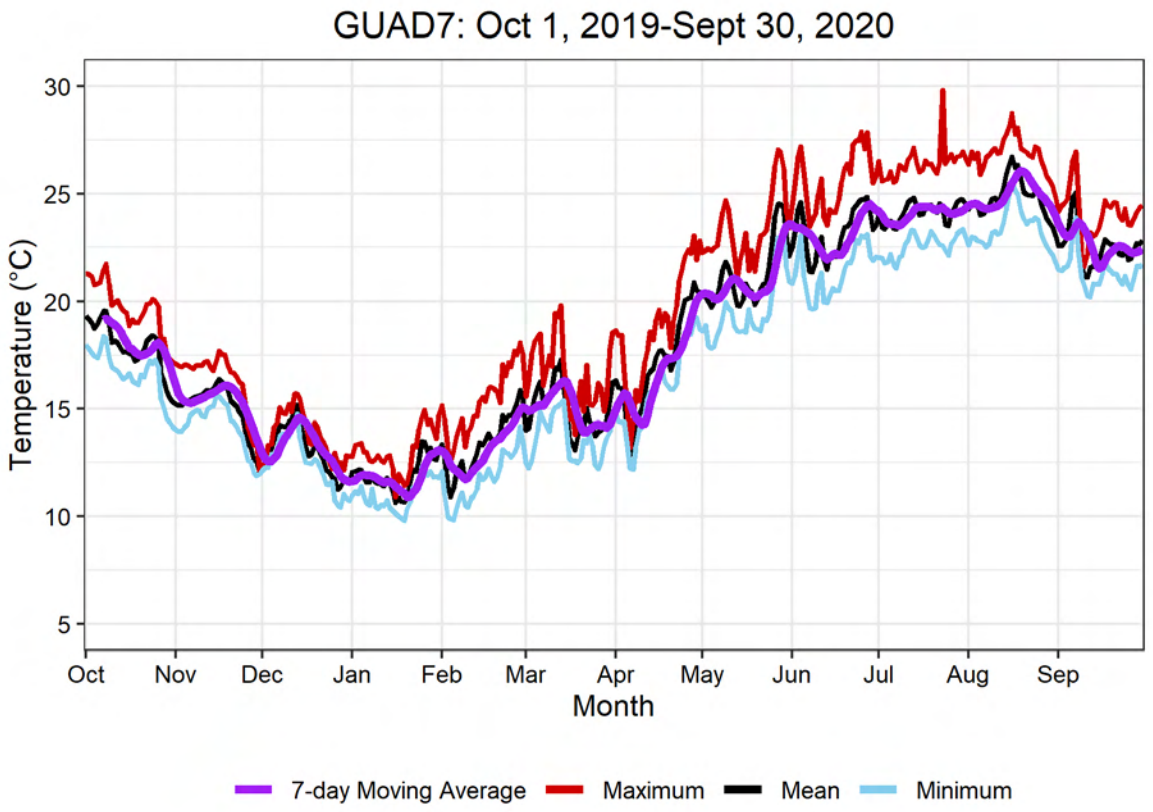


Figure 9. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GUAD7.

Guadalupe River Discussion

All stations showed a similar trend where temperatures decreased from the beginning of the Water Year until the end of January, increased up to mid-August, then plateaued or somewhat decreased until the end of the Water Year; however, the rate of change differed slightly among stations. This general temperature trend is considered typical for the region.

No clear temperature pattern was detected along the length of the Guadalupe River as temperature conditions at the most downstream station (GUAD1) were similar to those at some of the more upstream stations (GUAD4−GUAD7). Nevertheless, there were a couple notable observations from the stream temperature data. Stations GUAD2 and GUAD3 experienced lower average daily fluctuations and lower MWATs than the other stations. This mute diurnal swing and cooler temperatures are likely a result of high groundwater and associated groundwater discharges that occur throughout downtown San Jose. In contrast, GUAD6 and GUAD7 had higher MWATs and overall ranges than the remaining monitoring stations.

Across all monitoring stations, daily ranges were greatest from mid-June to mid-August with large gaps present between daily minimum and maximum temperatures. This trend was most pronounced at monitoring station GUAD4. We are unsure if these diurnal fluctuations are normal or a result of deployment methods; therefore, we are in the process of testing new housings (i.e., PVC pipe) and deployment strategies to determine whether these fluctuations are typical during summer months or an error associated with the monitoring equipment.

Guadalupe Creek

GCRK1

Station GCRK1 is the most downstream monitoring station on Guadalupe Creek and is located approximately 30 ft upstream of Almaden Expressway in San Jose. This station is roughly 0.6 mi downstream of *O. mykiss* juvenile rearing monitoring site GC001 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 10. In Water Year 2020, stream temperatures ranged from 7.9 to 27.1°C with an average daily fluctuation of 3.7°C. The MWAT for station GCRK1 during the monitoring period was 22.8°C.

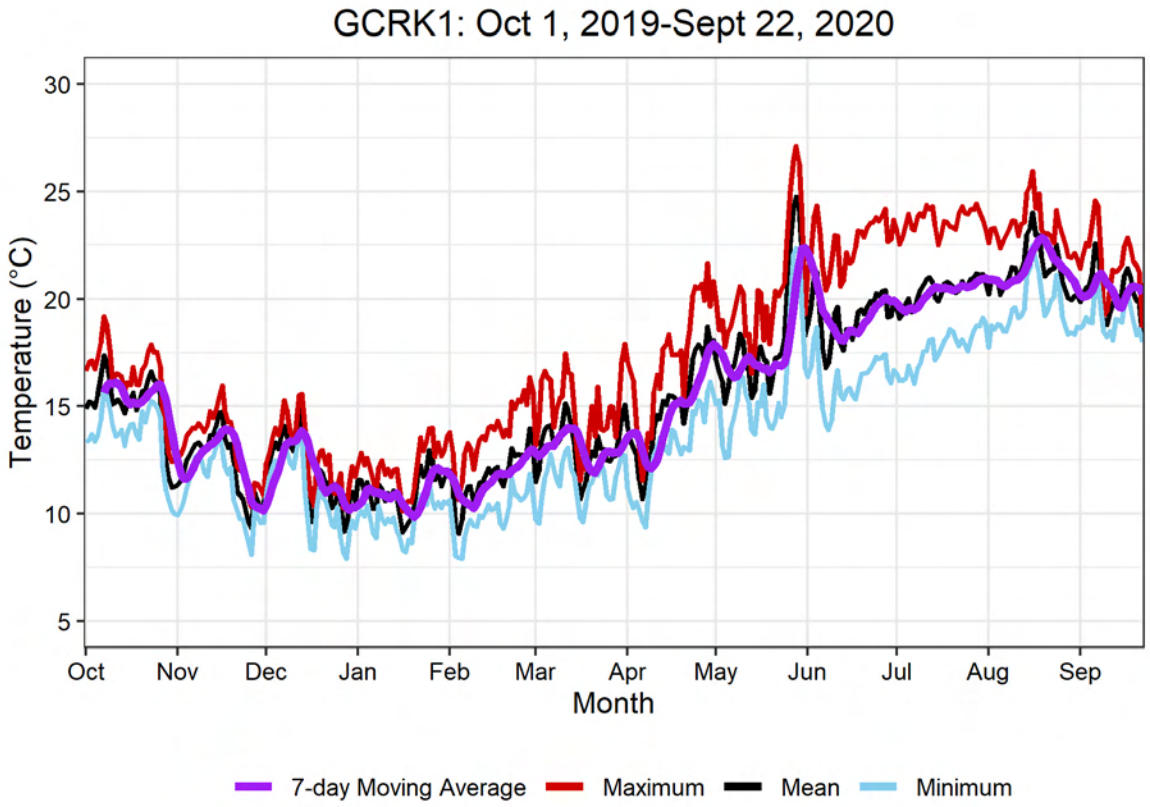


Figure 10. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GCRK1.

GCRK2

Station GCRK2 is located upstream of GCRK1 and approximately 0.6 mi upstream of Meridian Avenue next to the Los Capitancillos percolation ponds in San Jose. This station is immediately upstream of 2020 *O. mykiss* juvenile rearing monitoring site GC002 (see Valley Water 2021a). Temperature data for Water Year 2020 was only available until June 2, 2020 as this was the last date that data was downloaded before the logger was discovered missing on Sept. 22, 2020. Because the creek was dry at this location in September, a new logger was not deployed until after the Water Year when flows returned. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 11. Between Oct. 1, 2019 and June 2, 2020, stream temperatures ranged from 5.5 to 21.2°C with an average daily fluctuation of 2.4°C. The MWAT for station GCRK2 during the monitoring period was 17.9°C.

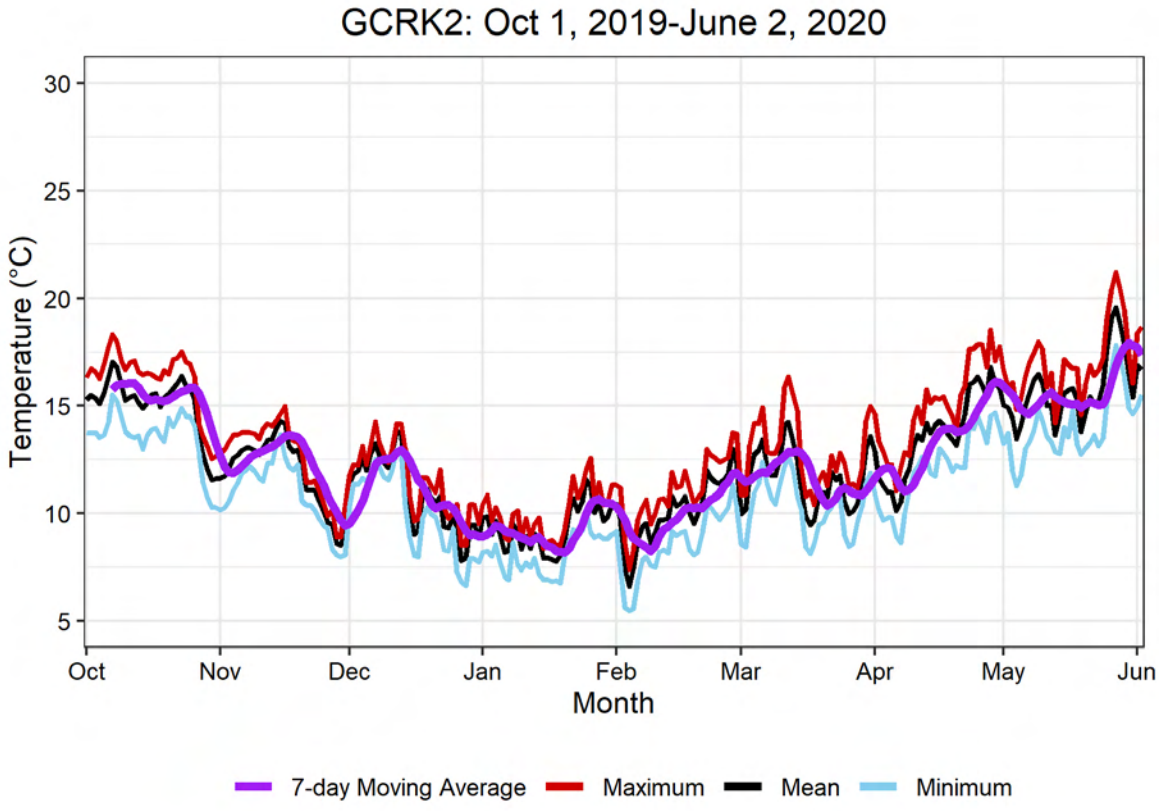


Figure 11. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GCRK2.

GCRK3

Station GCRK3 is located upstream of GCRK2 and approximately 1,000 ft downstream of Coleman Road in San Jose. This station is immediately upstream of *O. mykiss* juvenile rearing monitoring site GC003 (see Valley Water 2021a). Due to a manual error, the logger did not collect any temperature data until after June 2, 2020 when the error was corrected. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 12. Between June 2 and when the data was downloaded on Sept. 22, 2020, stream temperatures ranged from 12.3 to 24.7°C with an average daily fluctuation of 2.7°C. The MWAT for station GCRK3 during the monitoring period was 22.0°C.

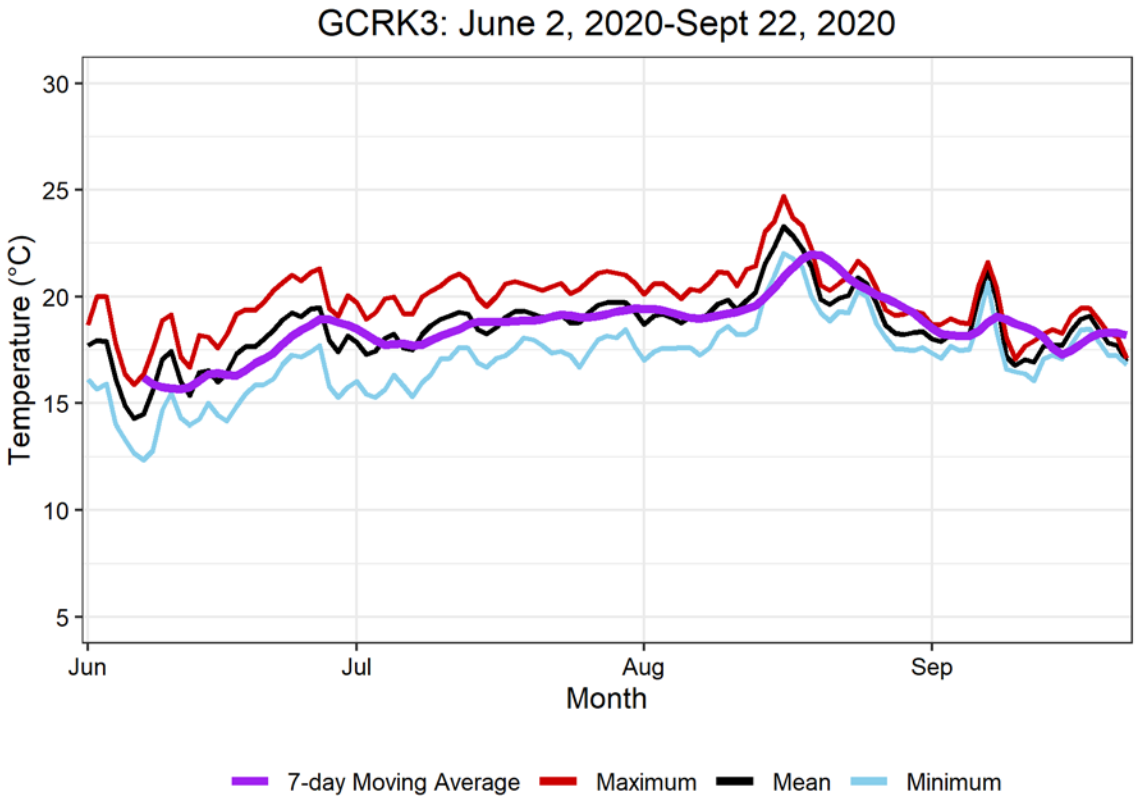


Figure 12. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GCRK3.

GCRK5

Station GCRK5 is located upstream of GCRK3 and approximately 700 ft upstream Guadalupe Creek's confluence with Pheasant Creek. This station is within *O. mykiss* juvenile rearing monitoring reach GC005 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 13. In Water Year 2020, stream temperatures ranged from 5.9 to 25.0°C with an average daily fluctuation of 2.9°C. The MWAT for station GCRK5 during the monitoring period was 22.0°C.

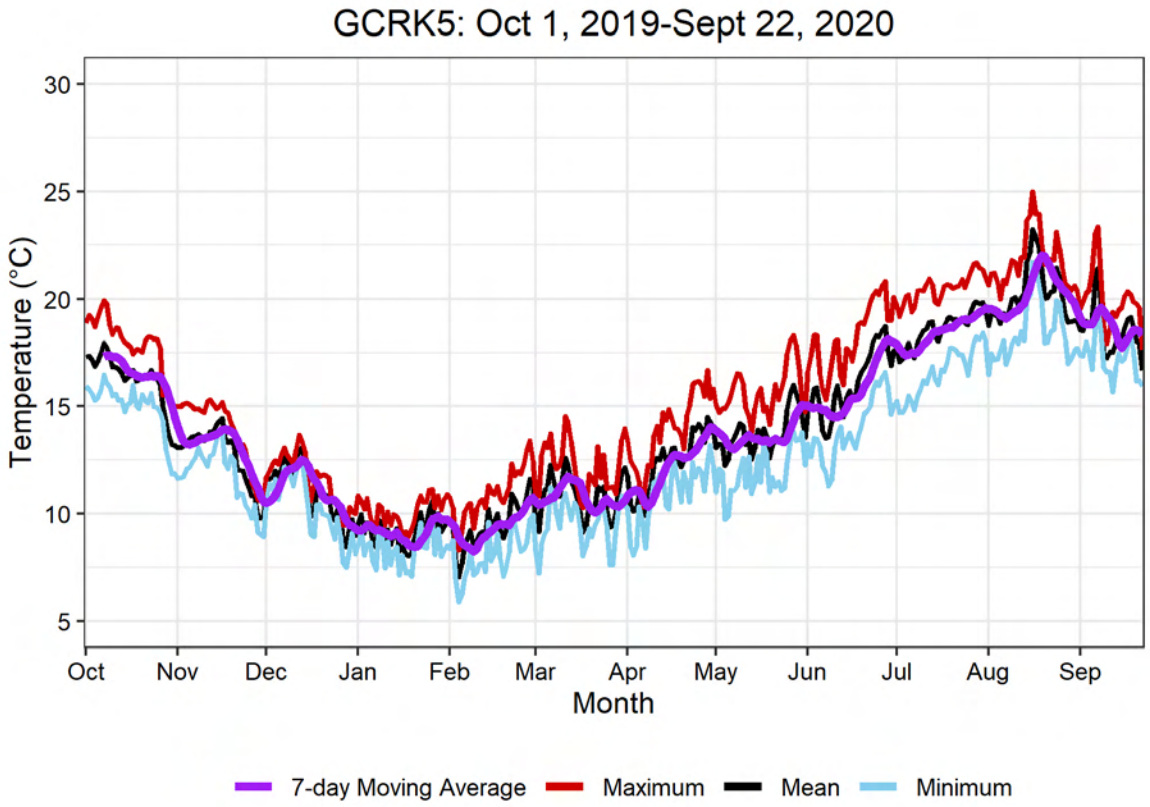


Figure 13. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GCRK5.

GCRK4

Station GCRK4 is the most upstream monitoring station on Guadalupe Creek and is approximately 300 ft downstream of the Guadalupe Reservoir outlet. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 14. In Water Year 2020, stream temperatures ranged from 8.9 to 25.2°C with an average daily fluctuation of 0.4°C. The MWAT for station GCRK4 during the monitoring period was 24.8°C.

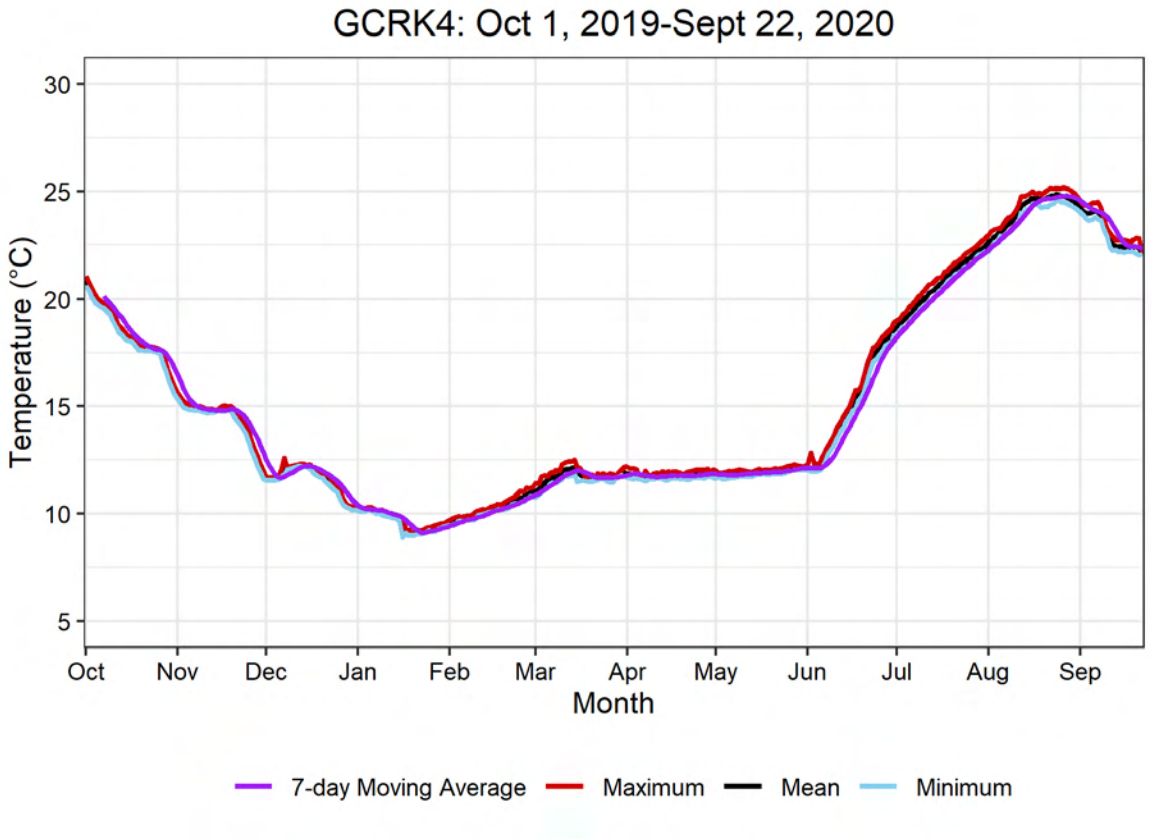


Figure 14. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station GCRK4.

Guadalupe Creek Discussion

Like the Guadalupe River, all stations showed a similar trend where temperatures decreased from the beginning of the Water Year to the end of January, increased until mid-August, then started to decline until the end of the Water Year, with the rate of change differing slightly among stations.

There were no apparent temperature patterns along the length of Guadalupe Creek as average daily fluctuations and MWATs were similar among most stations. GCRK4 (most upstream), however, showed much lower daily variation than the other stations. This result is to be expected due to its proximity to the outlet of Guadalupe Reservoir. Guadalupe Reservoir is a bottom release reservoir, and as a result of the thermal buffering caused by the reservoir pool, releases water that is more consistent in temperature.

GCRK2 had a substantially lower MWAT in comparison to the rest of the monitoring stations since available temperature data ended on June 2 before peak summer temperatures could be recorded. Now that the missing logger has been replaced, we expect to have a more complete dataset, and thus more accurate MWAT, for GCRK2 in Water Year 2021. Similarly, GCRK3 temperature results were influenced by missing data. Because temperatures were only recorded after June 2, the lack of winter temperature data resulted in a smaller overall range and higher minimum temperature value at GCRK3. With the logger error corrected, a full dataset should be available for Water Year 2021.

Across all monitoring stations that had summer data available (excluding GCRK4), daily ranges were greatest from mid-June to mid-August with large gaps present between daily minimum and maximum temperatures. This trend was most pronounced at monitoring station GCRK1. We are unsure if these diurnal fluctuations are normal or a result of deployment methods; therefore, we are in the process of testing new housings (i.e., PVC pipe) and deployment strategies to determine whether these fluctuations are typical during summer months or an error associated with the monitoring equipment.

Alamitos Creek

ALAM1

Station ALAM1 is the most downstream monitoring station on Alamitos Creek and is located approximately 500 ft upstream of Almaden Lake in San Jose. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 15. In Water Year 2020, stream temperatures ranged from 9.3 to 25.0°C with an average daily fluctuation of 2.8°C. The MWAT for station ALAM1 during the monitoring period was 21.8°C.

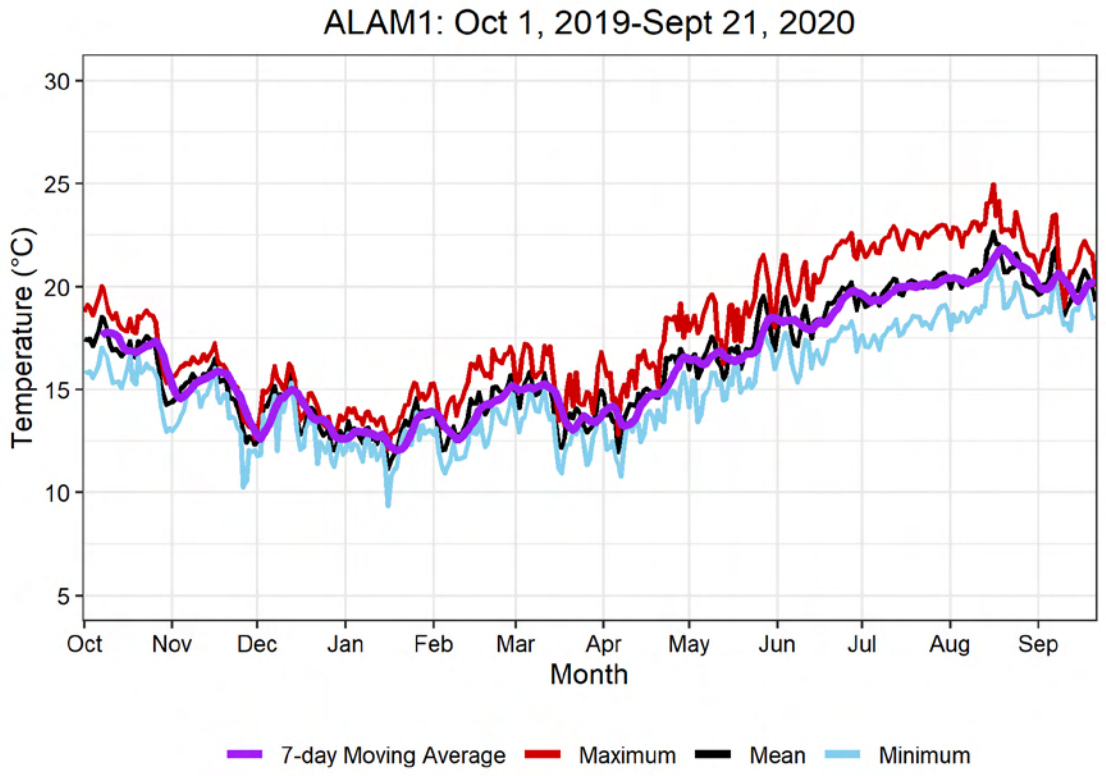


Figure 15. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM1.

ALAM5

Station ALAM5 located upstream of ALAM1 and approximately 400 ft upstream of Mazzone Drive in San Jose. This station is immediately upstream of Valley Water's Alamitos Creek PIT antenna and about 200 ft downstream of 2020 *O. mykiss* juvenile rearing monitoring site ACBONUS (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 16. In Water Year 2020, stream temperatures ranged from 9.1 to 25.7°C with an average daily fluctuation of 2.8°C. The MWAT for station ALAM5 during the monitoring period was 22.3°C.

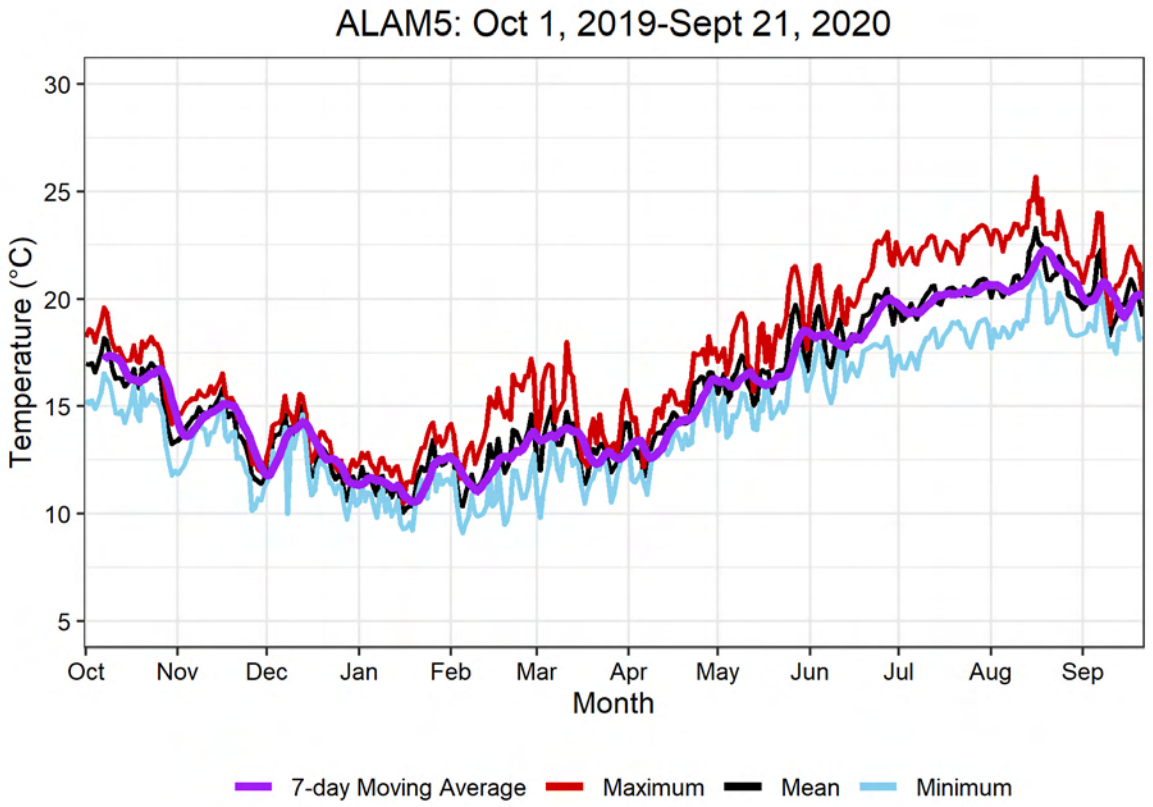


Figure 16. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM5.

ALAM6

Station ALAM6 is located upstream of ALAM5 and approximately 700 ft downstream of Graystone Lane in San Jose. This station is roughly 0.25 mi downstream of *O. mykiss* juvenile rearing monitoring site AC002 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 17. In Water Year 2020, stream temperatures ranged from 8.1 to 24.0°C with an average daily fluctuation of 2.8°C. The MWAT for station ALAM6 during the monitoring period was 21.6°C.

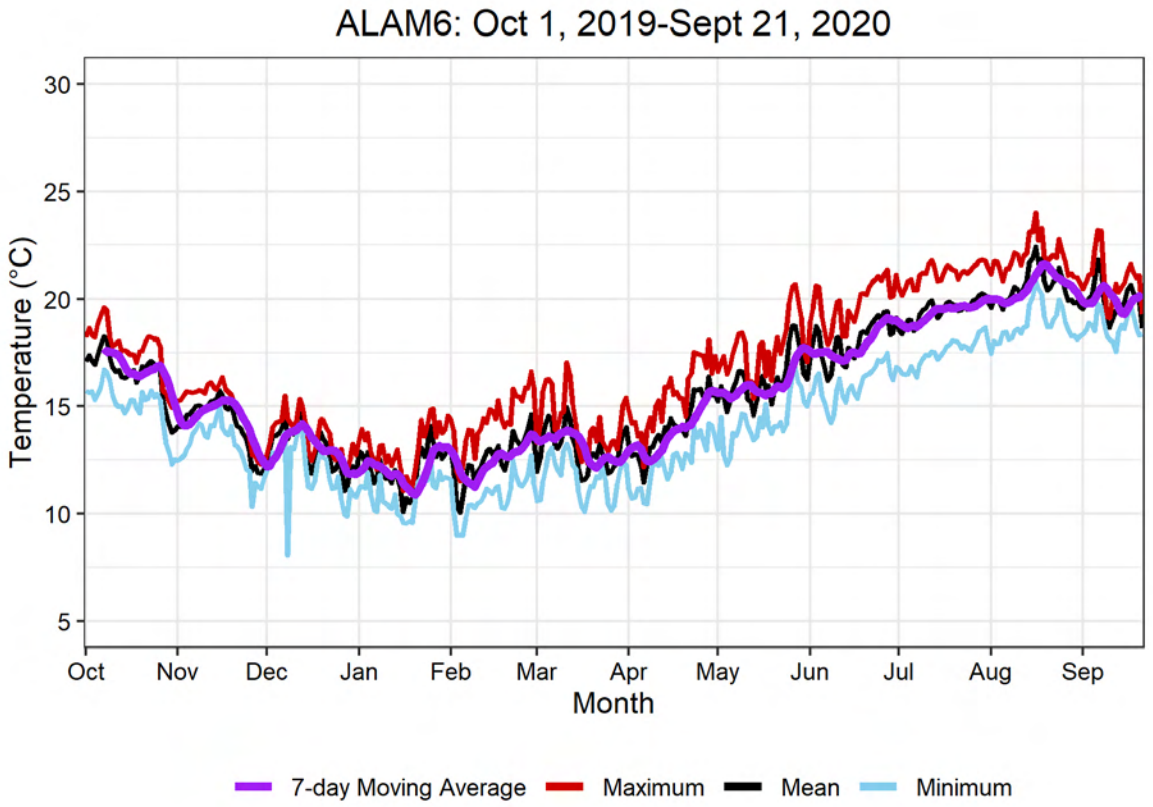


Figure 17. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM6.

ALAM2

Station ALAM2 is located upstream of ALAM6 and approximately 1,000 ft downstream of Alamitos Creek's confluence with Calero Creek. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 18. In Water Year 2020, stream temperatures ranged from 10.1 to 23.5°C with an average daily fluctuation of 2.3°C. The MWAT for station ALAM2 during the monitoring period was 21.2°C.

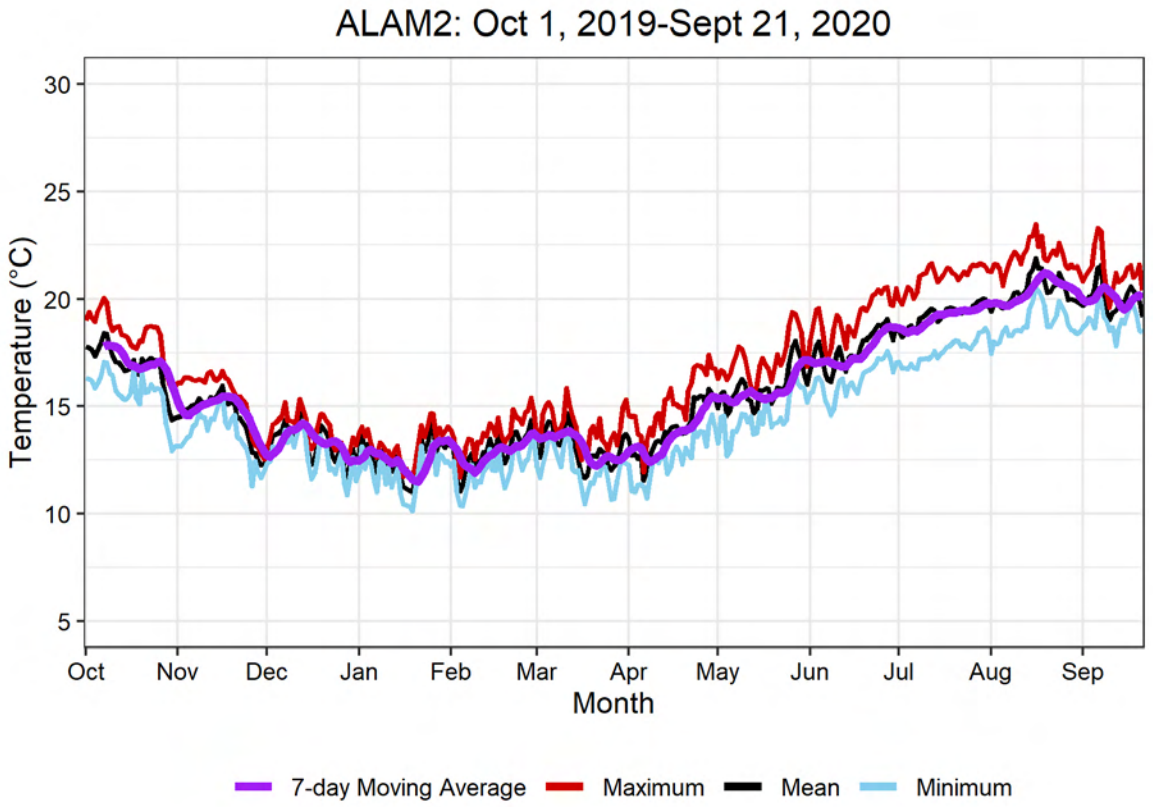


Figure 18. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM2.

ALAM3

Station ALAM3 is located upstream of ALAM2 and approximately 0.25 mi upstream of Camden Avenue in South San Jose. This station is roughly 500 ft downstream of *O. mykiss* juvenile rearing monitoring site AC003 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 19. In Water Year 2020, stream temperatures ranged from 5.7 to 26.5°C with an average daily fluctuation of 4.1°C. The MWAT for station ALAM3 during the monitoring period was 22.0°C.

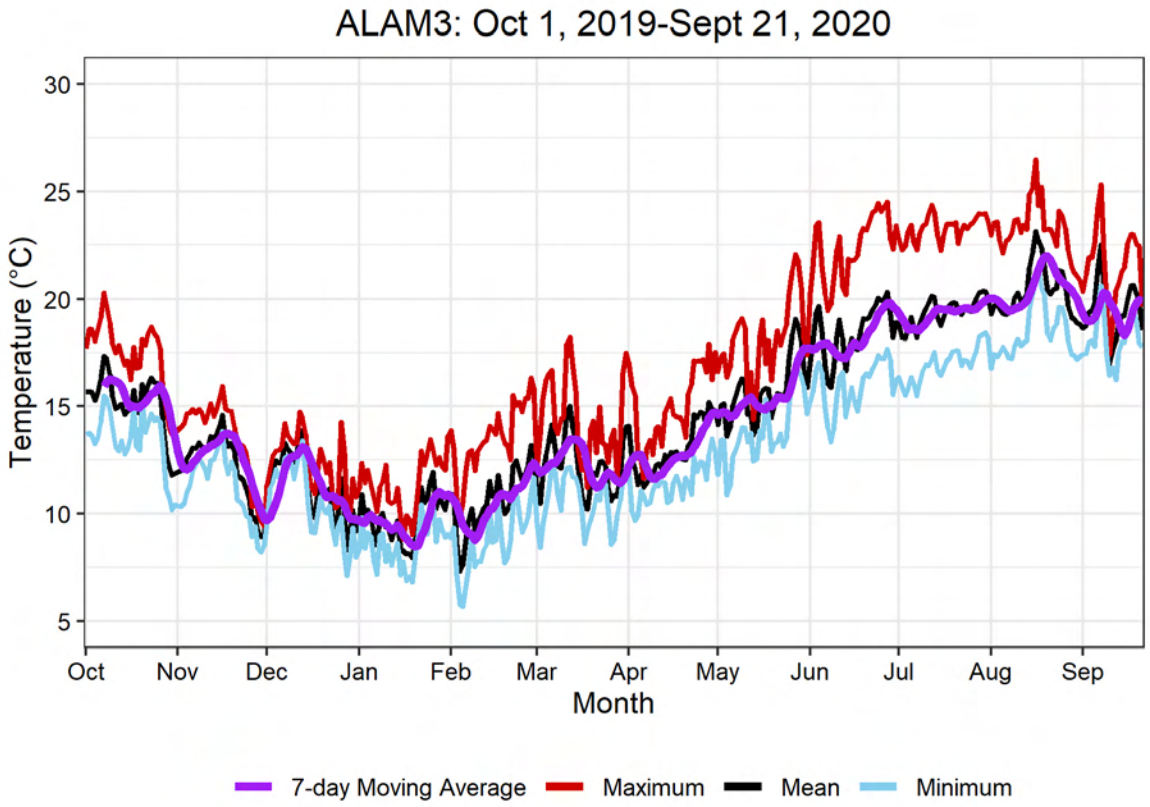


Figure 19. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM3.

ALAM4

Station ALAM4 is the most upstream monitoring station on Alamitos Creek and is located immediately downstream of the Almaden Reservoir outlet. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 19. In Water Year 2020, stream temperatures ranged from 8.5 to 22.5°C with an average daily fluctuation of 0.2°C. The MWAT for station ALAM4 during the monitoring period was 22.1°C.

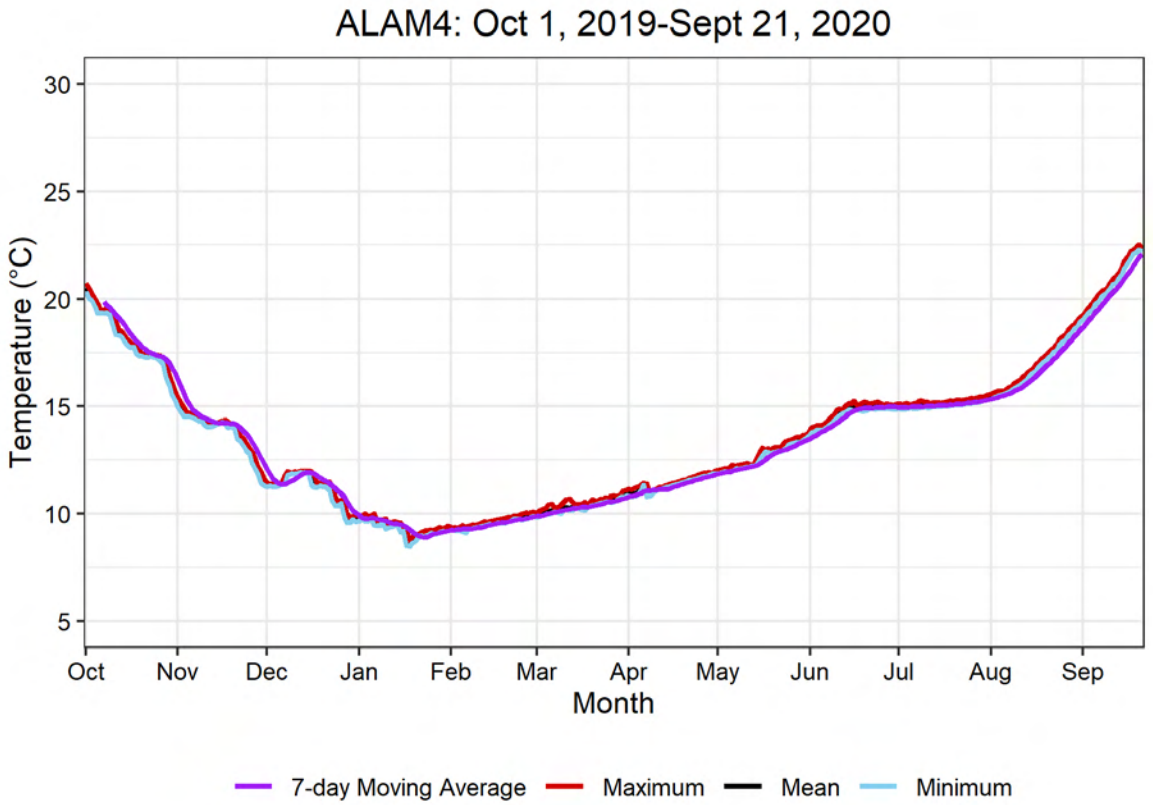


Figure 20. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station ALAM4.

Alamitos Creek Discussion

Like the Guadalupe River and Guadalupe Creek, all stations showed a similar trend where temperatures decreased from the beginning of the Water Year to the end of January, increased until mid-August, then started to decline until the end of the Water Year. The rate of change appeared to be comparable among stations.

There were no apparent temperature patterns along the length of Alamitos Creek as overall ranges, average daily fluctuations, and MWATs were similar among stations. However, ALAM4 (most upstream) showed much lower daily variation than the other stations. This result is to be expected due to its proximity to the outlet of Almaden Reservoir. Almaden Reservoir is a bottom release reservoir, and as a result of the thermal buffering caused by the reservoir pool, releases water that is more consistent in temperature.

Across all monitoring stations (excluding ALAM4), daily ranges were greatest from mid-June to mid-August with large gaps present between daily minimum and maximum temperatures. This trend was most pronounced at monitoring station ALAM3. We are unsure if these diurnal fluctuations are normal or a result of deployment methods; therefore, we are in the process of testing new housings (i.e., PVC pipe) and deployment strategies to determine whether these fluctuations are typical during summer months or an error associated with the monitoring equipment.

Los Gatos Creek

LOSG1

Station LOSG1 is the most downstream monitoring station on Los Gatos Creek and is located approximately 100 ft downstream of Lincoln Avenue in San Jose. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 21. In Water Year 2020, stream temperatures ranged from 7.4 to 28.4°C with an average daily fluctuation of 2.6°C. The MWAT for station LOSG1 during the monitoring period was 25.2°C.

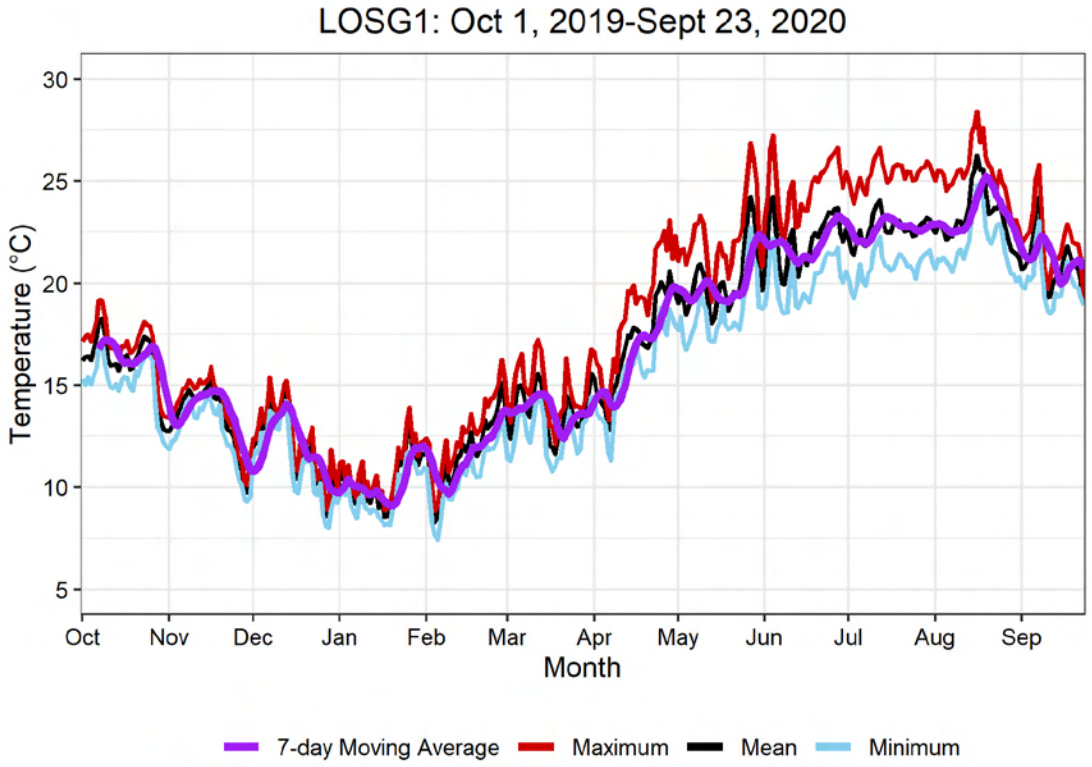


Figure 21. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station LOSG1.

LOSG3

Station LOSG3 is located upstream of LOSG1 and is approximately 150 ft downstream of Highway 17 in Campbell. This station is positioned within *O. mykiss* juvenile rearing monitoring reach LG004 (see Valley Water 2021a). During visual inspection of the data, anomalously high and low temperatures were observed on Oct. 15 and 16, presumably due to logger malfunction. As a result, these temperature readings were clipped from the dataset and excluded from analysis. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 22. In Water Year 2020, stream temperatures ranged from 8.8 to 27.6°C with an average daily fluctuation of 2.4°C. The MWAT for station LOSG3 during the monitoring period was 25.3°C.

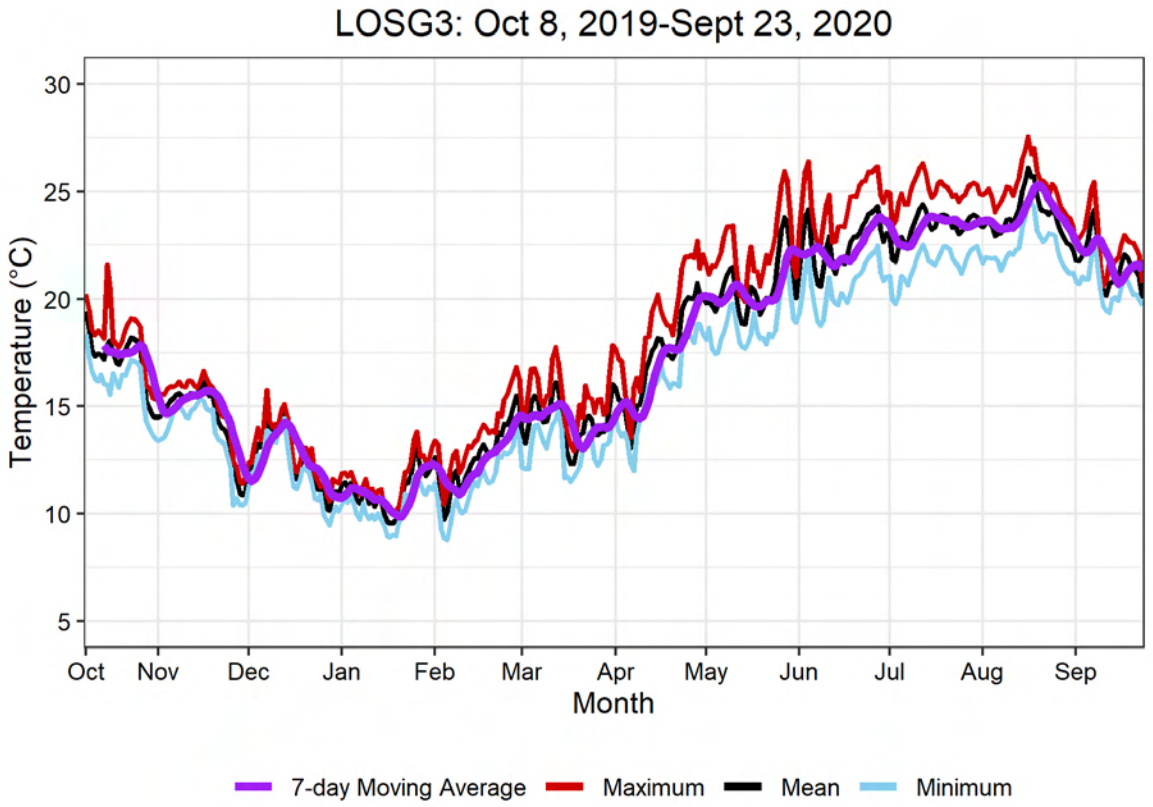


Figure 22. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station LOSG3.

LOSG2

Station LOSG2 is the most upstream monitoring station on Los Gatos Creek and is located approximately 200 ft downstream of the Camden Avenue Drop Structure. A temperature logger was installed at this station after Water Year 2020; therefore, there is no data to report for LOSG2 at this time.

Los Gatos Creek Discussion

As described in the previous systems, both stations on Los Gatos Creek showed a similar trend where temperatures decreased from the beginning of the Water Year to the end of January, increased until mid-August, then started to decline until the end of the Water Year. The rate of change appeared to be comparable between stations.

Temperature conditions seem to be consistent along Los Gatos Creek as LOSG1 and LOSG3 had very similar overall ranges, average daily fluctuations, and MWATs. However, definitive conclusions cannot be drawn since only two stations were active in Water Year 2020. We expect to have more knowledge of temperature patterns along Los Gatos Creek in Water Year 2021 when data from LOSG2 can be included.

At both monitoring stations LOSG1 and LOSG3, daily ranges were greatest from mid-June to mid-August with large gaps present between daily minimum and maximum temperatures. This trend was more pronounced at monitoring station LOSG1. We are unsure if these diurnal fluctuations are normal or a result of deployment methods; therefore, we are in the process of testing new housings (i.e., PVC pipe) and deployment strategies to determine whether these fluctuations are typical during summer months or an error associated with the monitoring equipment.

Calero Creek

CALE1

Station CALE1 is the most downstream monitoring station on Calero Creek and is approximately 700 ft upstream of the Alamitos Creek confluence. This station is roughly 200 ft downstream of *O. mykiss* juvenile rearing monitoring site CC001 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 23. In Water Year 2020, stream temperatures ranged from 9.2 to 24.2°C with an average daily fluctuation of 3.1°C. The MWAT for station CALE1 during the monitoring period was 21.5°C.

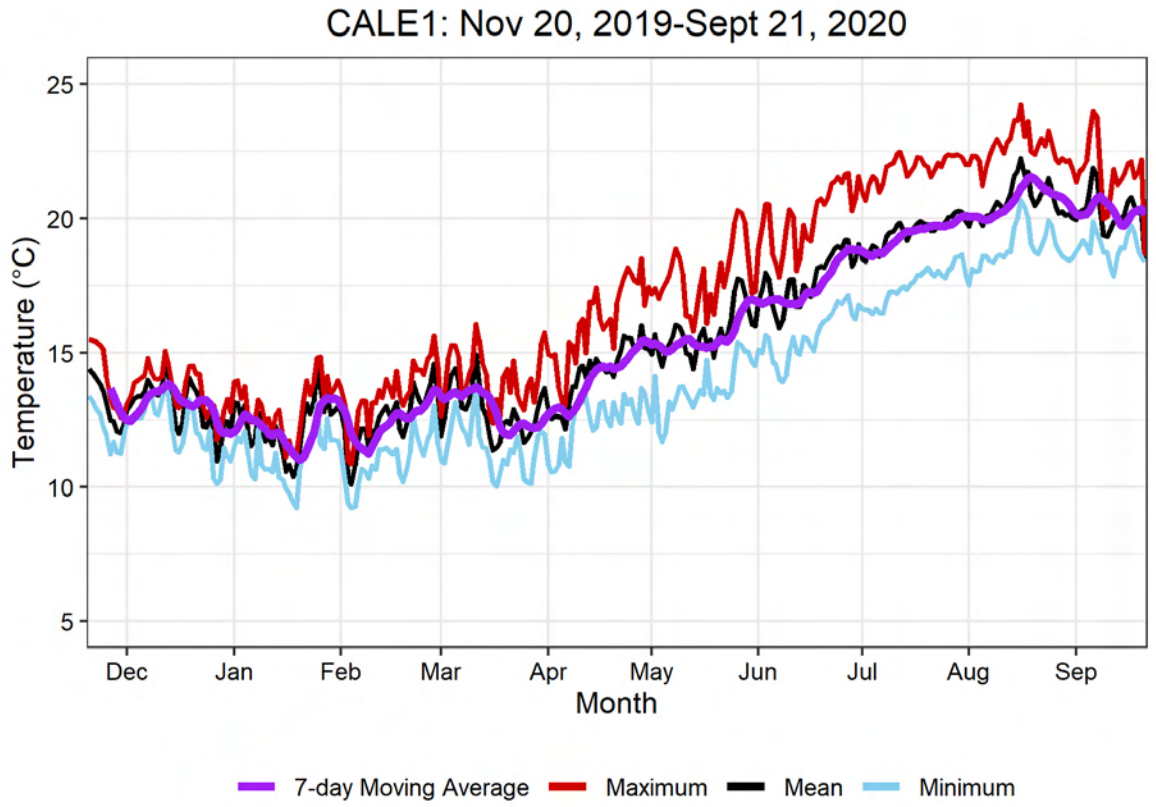


Figure 23. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station CALE1.

CALE3

Station CALE3 is located upstream of CALE1 and is approximately 0.5 mi upstream of Harry Road in South San Jose. This station is positioned within *O. mykiss* juvenile rearing monitoring reach CC003 (see Valley Water 2021a). Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 24. In Water Year 2020, stream temperatures ranged from 8.1 to 24.2°C with an average daily fluctuation of 3.5°C. The MWAT for station CALE3 during the monitoring period was 21.4°C.

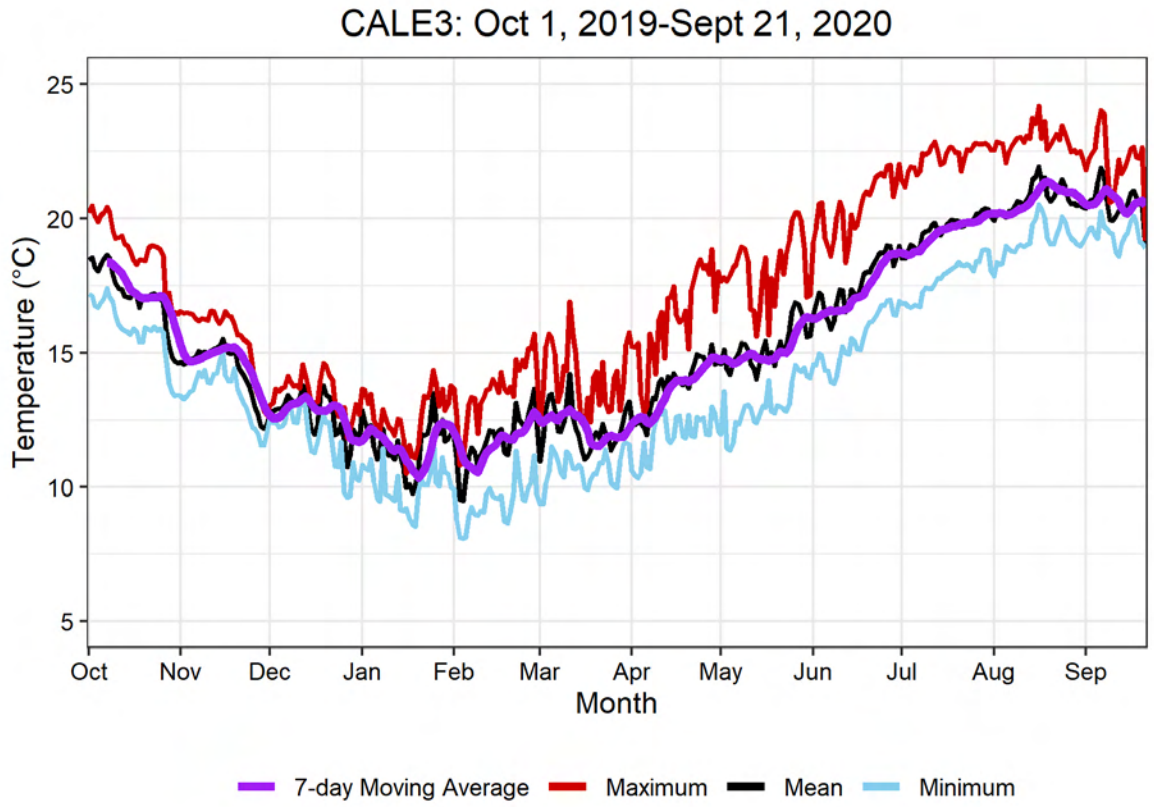


Figure 24. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station CALE3.

CALE2

Station CALE2 is the most upstream monitoring station on Calero Creek and is approximately 500 ft downstream of Calero Reservoir. Daily mean, minimum, and maximum temperatures, along with the 7-day moving average, are shown in Figure 25. In Water Year 2020, stream temperatures ranged from 9.3 to 22.1°C with an average daily fluctuation of 0.2°C. The MWAT for station CALE2 during the monitoring period was 21.8°C.

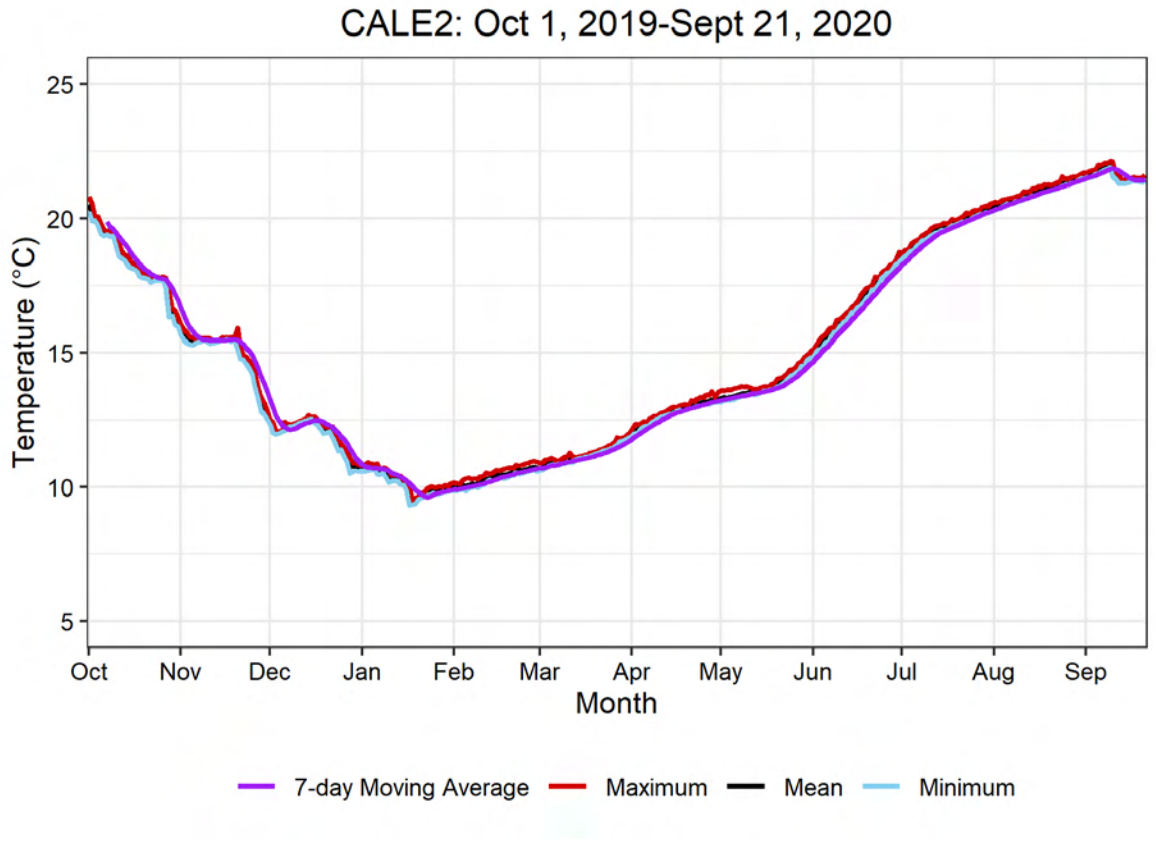


Figure 25. Daily mean, minimum, and maximum temperatures and 7-day moving average at monitoring station CALE2.

Calero Creek Discussion

All stations showed a similar trend where temperatures decreased from the beginning of the Water Year to the end of January, increased until mid-August, then started to decline until the end of the Water Year. The rate of change appeared to be comparable among stations.

There were no apparent temperature patterns along the length of Calero Creek as overall ranges and MWATs were similar among stations. However, CALE2 (most upstream) showed much lower daily variation than the other two stations. This result is to be expected due to its proximity to the outlet of Calero Reservoir. Calero Reservoir is a bottom release reservoir, and as a result of the thermal buffering caused by the reservoir pool, releases water that is more consistent in temperature.

Similar to other systems in the watershed, daily ranges were greatest during the warmer months of the year (excluding CALE2). However, unlike the other systems where this trend was only present between mid-June and mid-August, large gaps between daily minimum and maximum temperatures also occurred in April and May in Calero Creek. We are unsure if these diurnal fluctuations are normal or a result of deployment methods; therefore, we are in the process of testing new housings (i.e., PVC pipe) and deployment strategies to determine whether these fluctuations are typical during summer months or an error associated with the monitoring equipment.

Conclusion

Within the Guadalupe River Watershed in Water Year 2020, Guadalupe Creek, Alamitos Creek, and Calero Creek supported multiple *O. mykiss* age classes and summer rearing was successful based on the results of Valley Water's juvenile rearing monitoring effort (Valley Water 2021a). Across the 13 juvenile rearing sites sampled in these creeks, a total of 75 *O. mykiss* were collected. The majority of individuals were young-of-the-year and determined to be in healthy condition based on the results of a fish condition analysis (Valley Water 2021b). The Guadalupe River Watershed is therefore capable of supporting the rearing and persistence of juvenile *O. mykiss*. Continuing to monitor stream temperatures in conjunction with juvenile rearing sampling and other fisheries monitoring efforts will be useful towards furthering our understanding of *O. mykiss* in the Guadalupe River Watershed.

As stream temperature monitoring continues over time and improvements to data collection methods are made, this information will provide valuable insights into evaluating long-term temperature trends, assessing the effectiveness of potential restoration projects, and informing *O. mykiss* management objectives.

References

Valley Water. 2021a. 2020 Juvenile *O. mykiss* Rearing Monitoring in the Guadalupe River Watershed.

Valley Water. 2021b. 2020 Guadalupe River Watershed Juvenile *O. mykiss* Fish Condition.

2020 Guadalupe River Watershed
Juvenile *Oncorhynchus mykiss* Fish Condition

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Appendices

Appendix A: Individual Measurements, Standard Weights (W_s), Relative Weights (W_r), and Black Spot Severity of *O. mykiss* Sampled During Fall 2020 Guadalupe River Watershed Juvenile Rearing Monitoring

Background

Fish condition is a measure of length and weight that represents the physiological or nutritional state of a fish and can be used to compare the effects of biotic and abiotic factors on the health of a population (Murphy et al. 1990, Cone 1989). For instance, the presence of generally plump fish may be indicative of favorable environmental conditions (high-quality habitat, ample prey availability, etc.), whereas thin fish may indicate less favorable conditions. Therefore, monitoring fish condition can be useful for informing management recommendations concerning fish populations.

Relationships between weight and length are often used for assessing population size structure and individual fish condition. Because fish weight is directly related to fish length, weight-length data is not only used to predict one from the other, but it can also be used as an indicator of an individual's fatness or condition by measuring the variation from the expected weight for a certain length (LeCren 1951). The traditional approach to assessing fish condition involves the use of a 'condition factor,' which employs a fixed ratio to describe the relationship between fish length and weight (Murphy et al. 1991). The commonly used Fulton's condition factor (K) (Fulton 1904) is calculated as:

$$K = W / L^3$$

Where W is weight and L is length. Though it has the advantage of being easy to calculate, Fulton's condition factor has its drawbacks. First, it assumes isometric growth (power = 3, fish shape does not change with growth), which is rarely the case for most fish species (Froese 2006). Second, it is highly length- and species-dependent; therefore, it can only be reliably used to compare individuals with similar lengths and is practically impossible to compare across species. LeCren (1951) developed the relative condition factor (K_n) to address these issues, which is calculated with the formula:

$$K_n = W / W' \times 100$$

Where W is the actual weight of the individual fish and W' is the predicted length-specific mean weight for the population under study. While this approach solved the

problem of comparing fish of different lengths and species, it is population-dependent and thus cannot be used to compare fish condition across populations.

The concept of ‘relative weight’ as a condition index was first introduced by Wege and Anderson (1978) for measuring the condition of largemouth bass (*Micropterus salmoides*). The relative weight approach compares fish weight to a benchmark, or standard weight, of that species based on weight-length data collected throughout its range. Wege and Anderson believed that relative weight had several advantages over other condition factors: 1) it is easy to calculate, 2) relative weight does not change with different units of measure, 3) standard weights compensate for inherent changes in body form, and 4) relative weight values can be compared between fish of different lengths and from different populations (Blackwell et al. 2000). For these reasons, the relative weight index has become widely used in recent years as a measure of fish condition.

Introduction

The 440 km^2 Guadalupe River Watershed begins in headwater tributaries near the summits of Loma Prieta and Mount Umunhum in the Santa Cruz Mountains, then flows north into the mainstem Guadalupe River before draining into South San Francisco Bay through Alviso Slough. The upper watershed areas are less developed than the lower reaches and experience a lower degree of anthropogenic disturbance. The northern portions of the watershed are comprised of the Santa Clara County valley floor. The majority of the valley floor is extensively urbanized with patches of undeveloped parks and open agricultural lands. Major tributaries in the Guadalupe River Watershed include Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek.

The Guadalupe River Watershed supports the federally threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*) distinct population segment (DPS) in five of its systems: Guadalupe River, Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek. The portion of the Guadalupe River between its confluence with San Francisco Bay and West Hedding Street in San Jose is designated as critical

habitat for the species (70 FR 52570, September 2005). To better understand the health of juvenile *O. mykiss* in the Guadalupe River Watershed, fish condition was analyzed for *O. mykiss* sampled during Valley Water's 2020 juvenile rearing monitoring season. The relative weight approach was used to evaluate fish condition due to its utility, the ease with which it can be calculated and analyzed, and its ability to be compared among populations.

Methods

Data Collection

In fall 2020, length-weight data was collected from juvenile *O. mykiss* sampled during Valley Water's Guadalupe River Watershed index reach monitoring effort. The purpose of this annual monitoring effort is to document the abundance, distribution, and densities of *O. mykiss* in salmonid streams within the Guadalupe River Watershed. Sampling occurred in Guadalupe River and Alamitos, Calero, Guadalupe, and Los Gatos Creeks. *O. mykiss* were present in Alamitos Creek, Calero Creek, and Guadalupe Creek during fall 2020 sampling. For details on data collection methods, including sampling sites and fish processing procedures, please refer to the 2020 Juvenile *O. mykiss* Rearing Monitoring in the Guadalupe River Watershed report (Valley Water 2021).

Calculations

The standard weight for each fish was calculated from their measured length using the following standard weight equation developed for juvenile *O. mykiss* ranging from 50 to 200 mm fork-length (Duffy 2006):

$$\log_{10} W_s = -4.790 + 2.928 \log_{10} FL$$

Where W_s is the standard weight in grams and FL is the fork-length in millimeters. This standard weight equation was developed using weight-length data from 121 *O. mykiss* populations ranging from southern Alaska through central California (Duffy 2006), including populations within the CCC DPS. The equation was formed using the regression-line-percentile technique (Murphy et al. 1990), which is based on 75th-

percentile weights and uses $\log_{10}$ transformed data from a series of populations as the statistical population to be modeled (Blackwell et al. 2000).

The slope of the standard weight equation (b = 2.928) developed by Duffy (2006) indicates that juvenile *O. mykiss* ranging from Alaska through central California exhibit slight negative allometric growth (they become more elongated as they grow, $b < 3$), which defies the assumption of Fulton's condition factor of $b = 3$. In contrast, when $b > 3$, a fish experiences positive allometric growth and increases more in weight than predicted by its increase in length (it becomes more rounded as it grows) (Froese et al. 2011).

Standard weight was then used to calculate relative weight of individuals with the equation:

$$W_r = (W / W_s) \times 100$$

Where W_r is the relative weight and W is the weight of the fish being compared in grams. The factor 100 is used to express the equation as a percentage of W_s. Note that once $\log_{10}W_s$ was determined for each fish using the standard weight equation, the antilog of these values was used in the above equation to calculate W_r.

Individuals were then categorized into 25-mm fork-length classes (hereafter referred to as length classes) in order to analyze for any length-related condition trends in the populations sampled (Blackwell 2000).

Because many *O. mykiss* sampled in the watershed were infected with black spot disease[1], the relationship between black spot severity and W_r was assessed for the watershed as a whole to evaluate whether there was a negative correlation between black spot disease and fish condition.

The Kruskal-Wallis test was used to determine if there were statistically significant differences in W_r between creeks, between length classes for each creek, and between black spot severities ($p < 0.05$). Considered the nonparametric alternative to the one-

[1] Black spot disease is the common name for a parasitic infection of the developing stage, or metacercaria, of *Digenea* flatworms that produce a melanin-induced fibrous cyst (Schaaf et al. 2017). While effects of black spot disease on fish are not well understood, they are generally not believed to be harmful.

way ANOVA, the Kruskal-Wallis test was used for this study due to the non-normal data distributions and small sample sizes.

Relative Weight Target Range

The regression-line-percentile technique used to develop the standard weight equation above uses 75th-percentile weights; therefore, a W_r value of 100 (the actual weight of the fish equals the standard weight) is not an average-sized fish. Rather, it means that across their range, 25% of the juvenile *O. mykiss* will have a W_r value greater than 100 while 75% will be less than 100. A fish with a W_r of 100 is thus considered to be in better-than-average condition. For the original development of the W_r index (Wege and Anderson 1978), 75th-percentile weights were also used as a standard. Anderson (1980) subsequently recommended that 95−105 be used as a W_r target range in order to aim for fish populations that are in above average condition, and it has since been widely used by fisheries managers.

Nonetheless, Murphy et al. (1991) cautioned against using a universal target range for optimal condition, believing that “optimal” will vary according to specific management objectives and environmental limitations. Targets for W_r should therefore be established according to the management goals for a given program, but further research is needed to evaluate appropriate W_r target ranges for juvenile *O. mykiss* populations under various management scenarios.

For the purposes of this report, the W_r target range of 95−105 (Anderson 1980) was used to define fish in optimal condition. This W_r target range may be modified in the future as more data is collected and as management objectives for the Guadalupe River Watershed become established.

Interannual Comparisons

During 2018 and 2019 sampling in the Guadalupe River Watershed, juvenile *O. mykiss* were also present in Alamitos, Calero, and Guadalupe Creeks (SCVWD 2019, Valley Water 2020). The population W_r of juvenile *O. mykiss* in these creeks was compared between 2020 and previous sampling years to evaluate for any fish condition changes

over time. The Kruskal-Wallis test was used to look for significance between years; a significant Kruskal-Wallis test was followed by a post hoc Dunn's test to identify which years were significantly different.

Results

In total, 75 *O. mykiss* were sampled during the 2020 Guadalupe River Watershed juvenile rearing monitoring season (Alamitos Creek n = 24, Calero Creek n = 35, Guadalupe Creek n = 16). Summary statistics for measured weights and fork-lengths of fish sampled in each creek are provided in Table 1.

Table 1. Summary statistics of measured weights and fork-lengths for juvenile *O. mykiss* sampled in the Guadalupe River Watershed. Means are presented as the value ± SD. Sample size = n.

Creek	n	Mean Weight (g)	Weight Range (g)	Mean Fork-Length (mm)	Fork-Length Range (mm)
Alamitos	24	37.1 ± 44.2	1.4−162.5	130.8 ± 47.1	50−240
Calero	35	14.1 ± 49.0	2.9−295.5	81.9 ± 37.8	55−290
Guadalupe	16	13.0 ± 15.7	3.9–59.7	88.8 ± 34.2	56−184
Total	75	12.2 ± 13.0	1.4–295.5	90.8 ± 29.0	50−290

The standard weight equation developed by Duffy (2006) applies to juvenile *O. mykiss* between 50 and 200 mm fork-length. Four *O. mykiss* sampled from the Guadalupe River Watershed had a fork-length greater than 200 mm and were therefore excluded from the relative weight analysis (three from Alamitos Creek and one from Calero Creek). In addition, three individuals sampled from Guadalupe Creek were not weighed and their relative weight could not be assessed. Mean W_r was highest in Alamitos Creek at 107.7 (SD=17.8), followed by Calero Creek at 107.2 (SD=11.8) and Guadalupe Creek at 100.0 (SD=11.1). Summary statistics of W_r per creek are provided in Table 2 and distributions are shown in Figure 1.

Table 2. Summary statistics of juvenile *O. mykiss* W_r for Alamitos, Calero, and Guadalupe Creeks. Means are presented as the value ± SD. Sample size = n.

Creek	n	Mean W_r (%)	W_r Range (%)
Alamitos	21	107.7 ± 17.8	83.5−150.3
Calero	34	107.2 ± 11.8	84.1−153.3
Guadalupe	13	100.0 ± 11.1	82.2–120.1
No statistically significant differences in mean W_r among creeks (Kruskal-Wallis test; H = 3.01, df = 2, p = 0.221)			

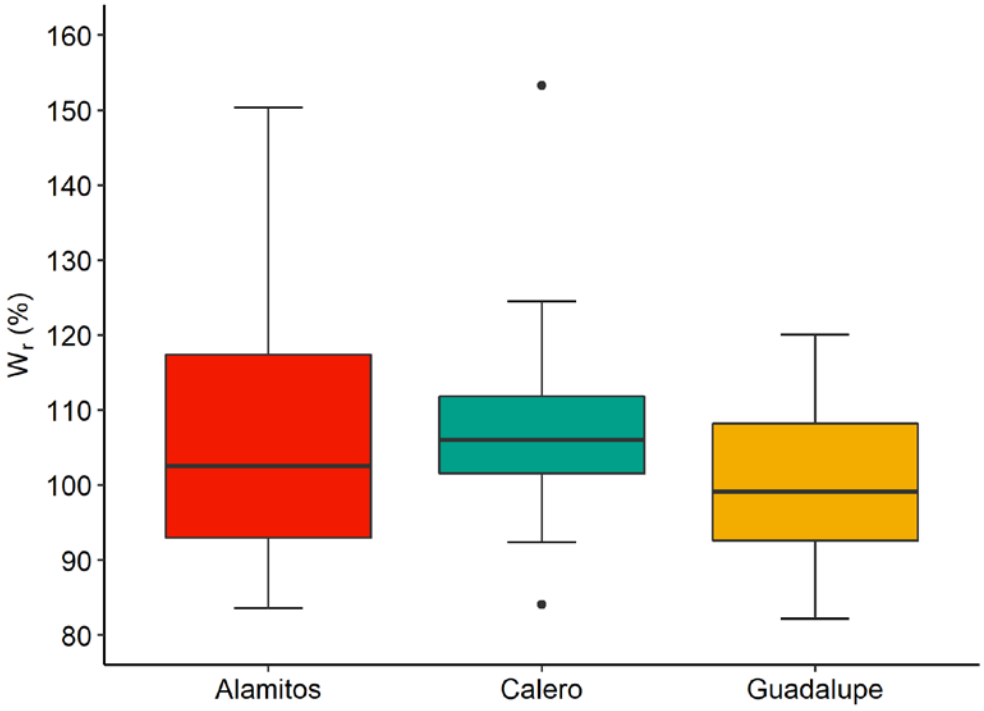


Figure 1. Boxplots (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges, and outlying points beyond whiskers) of relative weights (W_r) for juvenile *O. mykiss* sampled in Alamitos Creek (n = 21), Calero Creek (n = 34), and Guadalupe Creek (n = 13) within the Guadalupe River Watershed.

Relative weight plotted as a function of fork-length (Figure 2) revealed a slight negative length-related trend overall, but based on a linear regression analysis fork-length did not

have a significant effect on W_r for Alamitos Creek (adjusted R^2 = 0.009, 95% CI [-0.44, 0.14], p = 0.288) or Calero Creek (adjusted R^2 = 0.009, 95% CI [-0.59, 0.17], p = 0.264). In contrast, the effect of fork-length on W_r was statistically significant for Guadalupe Creek (adjusted R^2 = 0.4104, 95% CI [-0.37, -0.06], p = 0.011), where W_r decreased as fork-length increased.

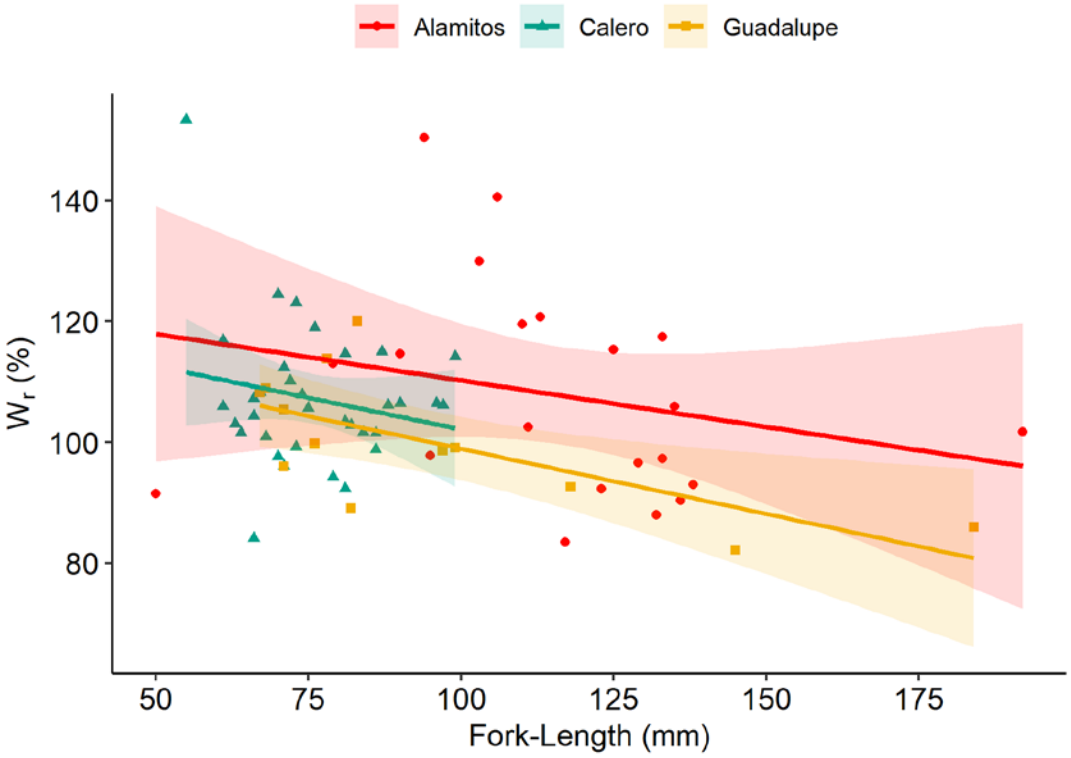


Figure 2. Relative weight (W_r) as a function of fork-length for juvenile *O. mykiss* sampled in Alamitos Creek (R^2 = 0.009), Calero Creek (R^2 = 0.009), and Guadalupe Creek (R^2 = 0.4104) within the Guadalupe River Watershed. Points, regression lines, and confidence bands are colored by creek.

Summary statistics for W_r per 25-mm length class are provided in Table 3 and distributions are shown in Figure 3. For all three creeks, there were no statistically significant differences in mean W_r among length classes as determined by a Kruskal-Wallis test (Alamitos: H = 5.42, df = 4, p = 0.248; Calero: H = 0.188, df = 1, p = 0.665; Guadalupe: H = 5.96, df = 4, p = 0.202).

Table 3. Summary statistics of Guadalupe River Watershed juvenile *O. mykiss* relative weights (W_r) per 25-mm length class. Means are presented as the value ± SD. Sample size = n.

Length Class (mm)	**n**	**Mean W_r (%)**	**W_r Range (%)**
Alamitos Creek			
≤50	1	91.52	91.52
76-100	4	118.95 ± 22.24	97.83−150.33
101-125	8	113.06 ± 19.12	83.54–140.51
126-150	7	98.38 ± 10.19	88.02–117.40
176-200	1	101.76	101.76
Calero Creek			
51-75	19	108.54 ± 14.31	84.10−153.31
76-100	15	105.52 ± 7.64	92.34−118.95
Guadalupe Creek			
51-75	4	104.64 ± 5.96	96.01−108.94
76-100	6	103.40 ± 11.36	89.08−120.07
101-125	1	92.59	92.59
126-150	1	82.19	82.19
176-200	1	86.02	86.02

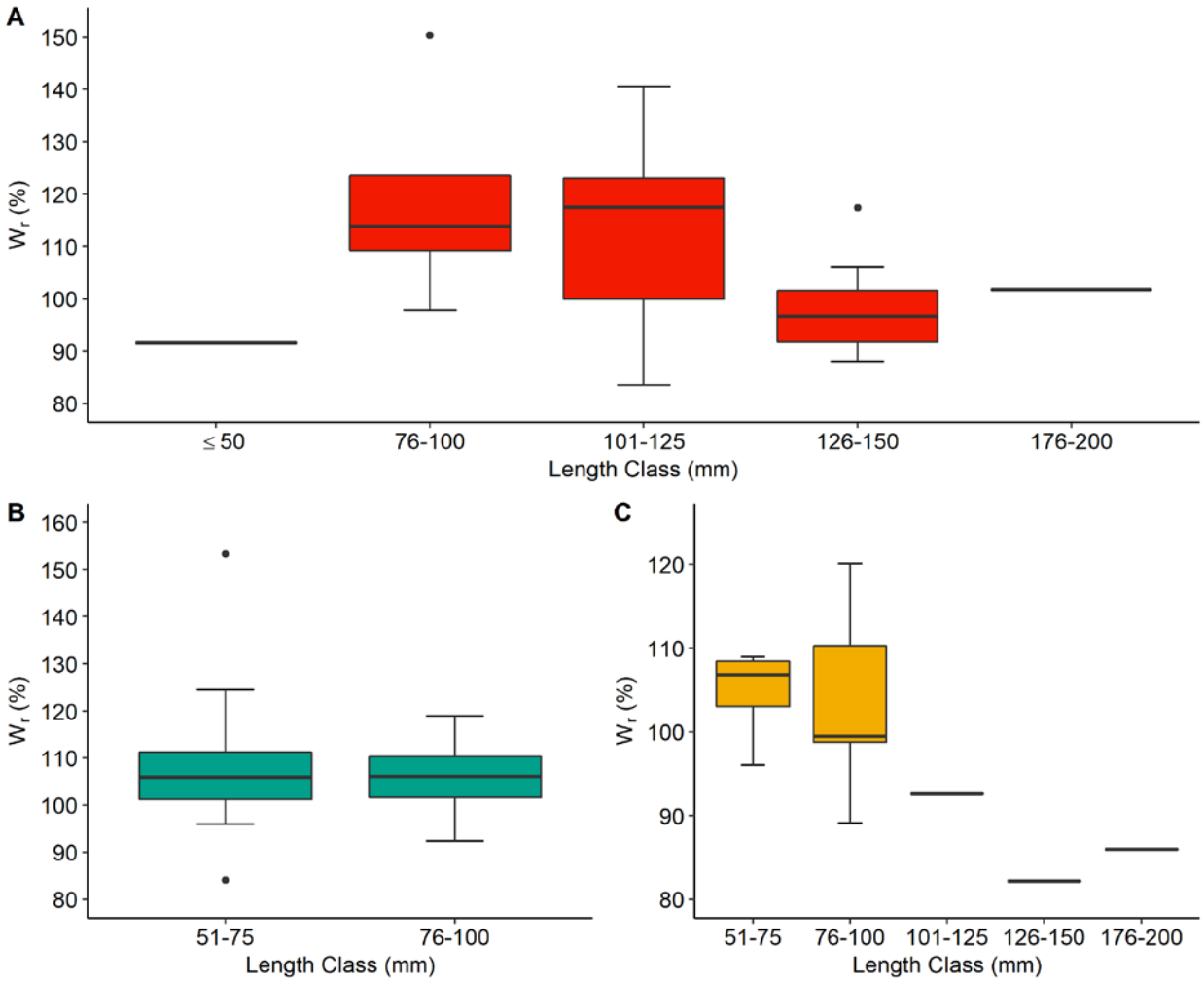


Figure 3. Boxplots (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges, and outlying points beyond whiskers) of juvenile *O. mykiss* relative weights (W_r) per 25-mm length class for A) Alamitos Creek, B) Calero Creek, and C) Guadalupe Creek.

Of the 75 *O. myiss* sampled in the Guadalupe River Watershed in 2020, 28 fish were infected with black spot (37%). Black spot severity was ranked on a scale of 0−3 where 0 = no infection, 1 = low infection (cysts cover <10% of the body), 2 = moderate infection (cysts cover 10-25% of the body), and 3 = severe infection (cysts cover >25% of the body) (Valley Water 2021). Black spot infection was most prevalent in fish sampled from Alamitos Creek. Out of the 28 total fish infected, 23 were from Alamitos Creek (82%) and 5 were from Guadalupe Creek (18%). Fifteen infected fish were ranked as 1; eight were ranked as 2, and five were ranked as 3. Black spot severity

appeared to have no effect on W_r as there were no statistically significant differences in mean W_r among severity ranks (Kruskal-Wallis test; H = 5.73, df = 3, p = 0.126) (Figure 4).

Individual fish measurements, W_s, W_r, and black spot severity are provided in Appendix A.

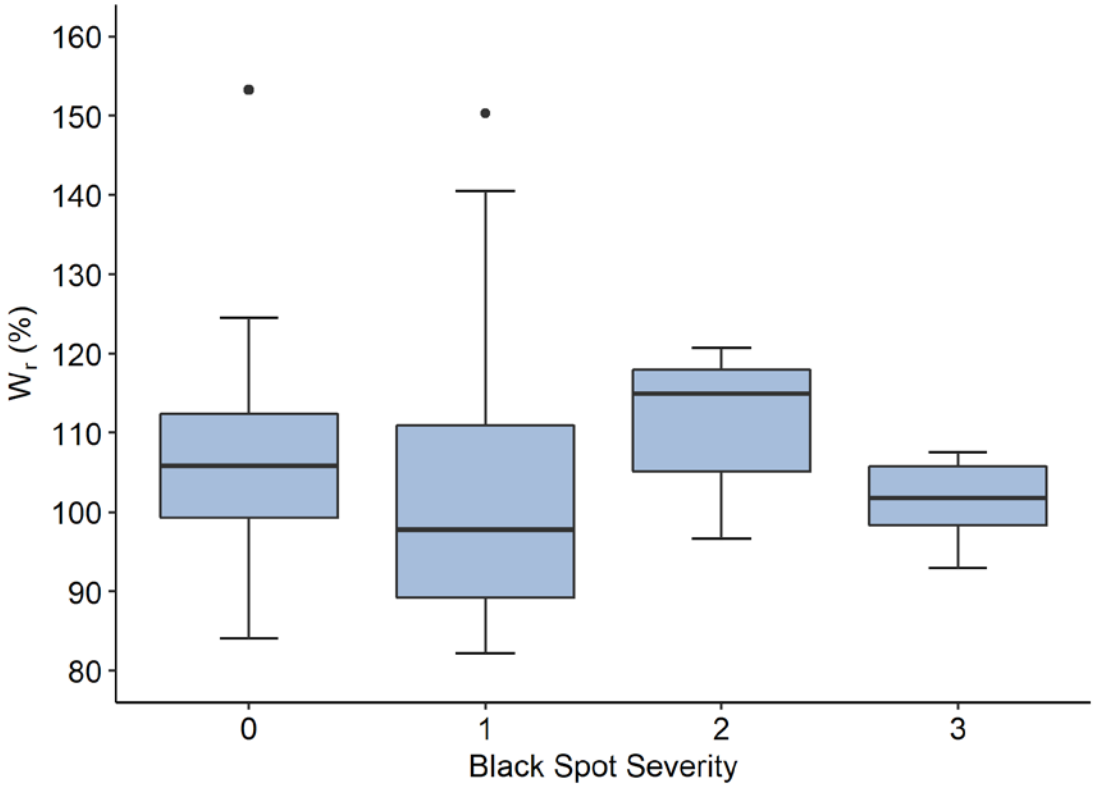


Figure 4. Boxplot (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges, and outlying points beyond whiskers) of juvenile *O. mykiss* relative weight (W_r) by black spot severity across all creeks in the Guadalupe River Watershed. Black spot severity scale is defined as: 0 = no infection, 1 = low infection, 2 = moderate infection, and 3 = severe infection (Valley Water 2021).

Mean W_r was highest in 2018 for both Calero Creek (120.2 ± 13.0) and Guadalupe Creek (119.4 ± 14.1), whereas 2019 showed the highest mean W_r for Alamitos Creek (114.1 ± 9.4). There were no significant differences in juvenile *O. mykiss* W_r between

any years in Alamitos Creek (Kruskal-Wallis test; H = 4.59, df = 2, p = 0.101). However, W_r of *O. mykiss* sampled in Calero Creek differed significantly between 2018 and 2020 (Dunn's test; p = 0.003), and Guadalupe Creek showed significant differences in W_r between 2018 and 2020 (Dunn's test; p = 0.0001) as well as 2019 and 2020 (Dunn's test; p = 0.007).

No significant differences were found between creeks in any year as determined by a Kruskal-Wallis test (2018: H = 7.72, df = 2, p = 0.052; 2019: H = 1.68, df = 2, p = 0.431; 2020: H = 3.02, df = 2, p = 0.221). Summary statistics for W_r by creek and year are provided in Table 4 and distributions are shown in Figure 5.

Table 4. Summary statistics of juvenile *O. mykiss* population W_r for Alamitos, Calero, and Guadalupe Creeks in 2018, 2019, and 2020. Means are presented as the value ± SD. Sample size = n.

Year	n	Mean W_r (%)	W_r Range (%)
Alamitos Creek			
2018	59	113.7 ± 13.5	92.1 – 166.2
2019	48	114.1 ± 9.4	99.4 – 148.5
2020	21	107.7 ± 17.8	83.5−150.3
Calero Creek			
2018	15	120.2 ± 13.0[a]	95.4 – 144.3
2019	7	111.0 ± 8.1	102.9 – 122.8
2020	34	107.2 ± 11.8[b]	84.1−153.3
Guadalupe Creek			
2018	66	119.4 ± 14.1[a]	86.5 – 152.3
2019	33	115.7 ± 11.6[a]	94.5 – 153.5
2020	13	100.0 ± 11.1[b]	82.2–120.1

Different letters indicate statistically significant differences between years (Kruskal-Wallis test followed by Dunn's test, $p < 0.05$).

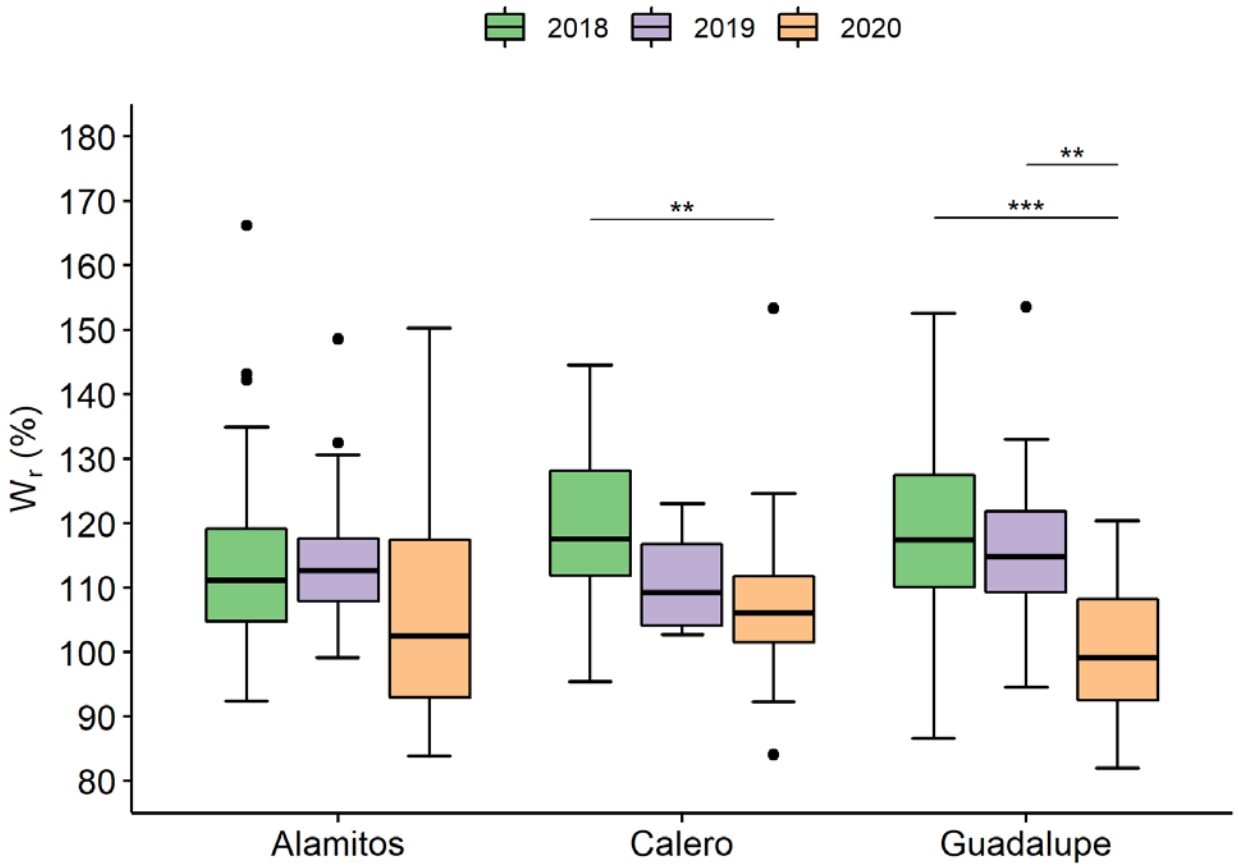


Figure 5. Boxplots (with the median, 25% and 75% quartiles, whiskers extending 1.5 times the interquartile ranges, and outlying points beyond whiskers) of relative weights (W_r) for juvenile *O. mykiss* sampled in Alamitos Creek, Calero Creek, and Guadalupe Creek within the Guadalupe River Watershed in 2018, 2019, and 2020. **Significance at the 0.01 probability level. ***Significance at the 0.001 probability level.

Discussion

Our results show that, in all creeks sampled, there were no significant differences in W_r among length classes. This suggests that juvenile *O. mykiss* condition in these systems does not differ substantially between fish of varying lengths/ages, but the large discrepancies in sample size among length classes should be noted when interpreting these results. Though length was not correlated to W_r in Alamitos and Calero Creeks, there was a negative correlation between the two variables in Guadalupe Creek, suggesting that the condition of juvenile *O. mykiss* in this system may decline as fish get larger. However, conclusions cannot reliably be made as only one fish was sampled in

each of the three largest length classes in Guadalupe Creek. As more data is collected, any length-related trends in fish condition will become more apparent.

Relative weight also did not differ significantly among levels of black spot severity, which indicates that black spot disease may not affect the health of juvenile *O. mykiss* in the Guadalupe River Watershed. The health effects of black spot disease on *O. mykiss* specifically have not been well-studied, and previous studies on salmonids and other freshwater species show mixed results regarding the extent to which the disease negatively impacts infected fish (Schaaf et al. 2017). For instance, Ferguson et al. (2012) found that it had no effect on juvenile coho salmon metabolism and growth, whereas studies with Centrarchids have found that it leads to significant weight loss and can be lethal at high infection levels (Hunter and Hamilton 1941, Lemly and Esch 1984). Though our results suggest that juvenile *O. mykiss* condition is not influenced by black spot severity, further data collection is warranted to draw reliable conclusions, especially since more than half of the infected fish only had a severity of 1. Continuing to assess the health effects of black spot disease in *O. mykiss* will be important given the potential for sub-lethal and lethal impacts reported in other species.

Mean W_r was comparable among populations and either at or above 100. These findings not only indicate that populations are in similar condition, but that overall they are healthy. While relative weights of individuals in the Guadalupe River Watershed ranged widely, values show that the majority of fish are in excellent condition with 83% of fish sampled (excluding fish >200 mm fork-length) falling either within or above the optimal W_r target range (95−105). Fish with a high W_r can signify a waterbody with conditions ideal for growth, such as suitable habitat and water quality and abundant prey (Murphy et al. 1990, Liao et al. 1995). Presence of physical habitat features like large woody debris and undercut banks can contribute to improved juvenile *O. mykiss* condition and survival by providing refugia from predators and high flow velocities. Water temperature can likewise influence fish condition and has been documented to impact growth and size of *O. mykiss* and other salmonids through effects on metabolism, behavior and mortality (Bjornn and Reiser 1991). Young of the year *O. mykiss* fed to satiation exhibited increased growth rates at increased temperatures (up

to 19º C) in a laboratory setting (Myrick and Cech 2005), and increased fall-spring temperatures (maximum temperature was approximately 11º C) were also shown to result in increased growth in *O. mykiss* (Railsback and Rose 1999). However, at extreme upper temperatures, growth may be reduced (Bjornn and Reiser 1991). According to NFMS (2016), optimal water temperatures for juvenile *O. mykiss* growth range from 12 to 19°C (~54 to 66°F), though the majority of research done on suitable temperatures for salmonids has been conducted in the Pacific Northwest where environmental conditions are much different than the Central California Coast. Earlier studies have also found relationships between W_r and food supply (Flickinger and Bulow 1993, Liao et al. 1995) and shown that prey biomass is positively correlated with fish condition.

Our high W_r results suggest that environmental conditions in the Guadalupe River Watershed are favorable for juvenile *O. mykiss.* Salmonid creeks in the watershed are known to have habitat complexity in the form of large woody debris, boulders, rootwads, undercut banks, and emergent vegetation (Vallley Water 2021), and stream temperatures in this region are within the range defined by NMFS (2016) for most of the year (excluding summer). Though no studies on *O. mykiss* prey abundance have been conducted in the watershed, our high W_r results imply that adequately-sized prey items are readily available.

Additionally, previous studies on salmonids have shown that fish weight or growth is inversely related to population density (Close and Anderson 1992, Keeley 2003), and that mean population W_r values are higher in areas where low densities of fish occur (Johnson et al. 1992). This is because individual fish weight and condition are likely to improve when there is reduced competition for food and other resources. During fall 2020 sampling, the estimated *O. mykiss* population densities in Alamitos and Guadalupe Creek were low compared to previous years at 0.12 *O*. *mykiss*/meter and 0.08 *O*. *mykiss*/meter, respectively. The population density in Calero Creek, however, was the highest estimated during the three-year sampling window (2018-2020) at an average of 0.29 *O*. *mykiss*/meter (Valley Water 2021). More definitive conclusions

regarding the influence of density on fish condition in these systems can be made as sampling continues.

It is worth noting that human error has the potential to skew the results. Accurately measuring the length and weight of fish can be difficult in the field, especially with small fish and when they need to be measured quickly. Furthermore, issues taring the scale in the field and excess water on the equipment (scale and measuring board) can affect the weight measurement.

Although the majority of individuals had a considerably high W_r, the results are within reason when compared to other populations of juvenile *O. mykiss* from Alaska through northern California. McLaughlin (2009) calculated the average W_r for over 100 juvenile *O. mykiss* populations of various sizes throughout northern California, Oregon, Washington, and Alaska. Average W_r for populations in McLaughlin's dataset ranged from 78.2 to 118.1 with an average of 97.7. The 2020 sampled populations in Alamitos, Calero, and Guadalupe Creeks had an average W_r of 107.2, 107.7, and 100.0, respectively, and thus fall within the aforementioned range.

In comparison to previous sampling years in the Guadalupe Watershed, juvenile *O. mykiss* sampled in 2020 had the lowest mean W_r in all three creeks; however, the difference between W_r in 2020 and other sampling years was not always statistically significant. These differences can be due to a range of factors, such as variations in sampling procedures and environmental variables, but the discrepancies in sample size between years should also be taken into account when interpreting these results. Moreover, juvenile *O. mykiss* in all sampling years were still in excellent condition despite any significant differences with mean population relative weights equaling or exceeding 100. Interannnual trends are difficult to assess at this time, and more conclusive comparisons will become possible as more data is collected.

With continued juvenile *O. mykiss* rearing sampling in the watershed, any climatic variation (e.g., dry, warm years vs. wet, cold years) and operational changes (e.g., flow releases or reductions) can also be incorporated into the results to determine if there is any correlation between these factors and fish condition. By using W_r as a condition index, we were able to make direct comparisons among fish of different lengths and

across populations and years, and thus summarize the overall health of juvenile *O. mykiss* in the Guadalupe River Watershed. The W_r approach also provides future opportunities for comparisons to be made between these systems and other *O. mykiss* populations in Santa Clara County.

Overall, juvenile *O. mykiss* sampled in the Guadalupe River Watershed in 2020 and previous sampling years were in healthy condition, indicating that environmental conditions within the watershed are favorable for supporting the growth and persistence of juvenile *O. mykiss*.

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Appendix A

Individual Measurements, Standard Weights (W_s), Relative Weights (W_r), and Black Spot Severity of *O. mykiss* Sampled During Fall 2020 Guadalupe River Watershed Juvenile Rearing Monitoring

FishID	Weight (g)	Fork-Length (mm)	W_s (g)	W_r (%)	Site	Black Spot Severity
Alamitos Creek						
2020ALM001	19.4	106	13.81	140.51	AC002	1
2020ALM002	16.5	103	12.69	129.99	AC002	1
2020ALM003	14.6	94	9.71	150.33	AC002	1
2020ALM004	26.1	133	26.83	97.28	AC002	1
2020ALM005*	157.8	239	–	–	AC001	3
2020ALM006	80	192	78.62	101.76	AC001	3
2020ALM007*	162.5	240	–	–	AC001	3
2020ALM008	16.2	111	15.80	102.52	AC001	2
2020ALM009	9.8	95	10.02	97.83	ALMSMP01	1
2020ALM010	27.8	138	29.89	93.00	ALMSMP01	3
2020ALM011	25.8	125	22.37	115.31	ALMSMP01	2
2020ALM012	15.4	117	18.44	83.54	AC004	1
2020ALM013	25.9	136	28.64	90.43	AC004	1
2020ALM014	23.1	132	26.24	88.02	AC004	1
2020ALM015	6.6	79	5.84	113.06	AC004	1
2020ALM016	19.7	123	21.34	92.30	AC004	1
2020ALM017	1.4	50	1.53	91.53	AC004	0
2020ALM018	29.7	135	28.03	105.96	AC003	2
2020ALM019	20.1	113	16.65	120.72	AC003	2
2020ALM020	9.8	90	8.55	114.61	AC003	2
2020ALM021	23.7	129	24.54	96.59	AC003	2
2020ALM022	31.5	133	26.83	117.40	AC003	2
2020ALM023	18.4	110	15.39	119.57	AC003	2
2020ALMRecap*	107.7	215	–	–	AC003	3
Calero Creek						
2020CAL001	7.2	81	6.28	114.63	CC003	0
2020CAL002	4	70	4.10	97.64	CC003	0
2020CAL003	4.8	71	4.27	112.40	CC003	0
2020CAL004	3.1	55	2.02	153.31	CC003	0
2020CAL005	5.2	74	4.82	107.87	CC003	0
2020CAL006	5.5	79	5.84	94.21	CC003	0
2020CAL007	3.7	66	3.45	107.29	CC003	0

FishID	Weight (g)	Fork-Length (mm)	W_s (g)	W_r (%)	Site	Black Spot Severity
2020CAL008	3.8	68	3.76	100.97	CC003	0
2020CAL009	8.9	87	7.74	114.94	CC003	0
2020CAL010	5.1	70	4.10	124.49	CC003	0
2020CAL011*	295.5	290	–	–	CC003	0
2020CAL012	2.9	66	3.45	84.10	CC003	0
2020CAL013	3.9	67	3.60	108.22	CC003	0
2020CAL014	3.2	64	3.15	101.54	CC003	0
2020CAL015	5.8	81	6.28	92.34	CC003	0
2020CAL016	2.9	61	2.74	105.91	CC002	0
2020CAL017	7.6	86	7.49	101.53	CC002	0
2020CAL018	4.9	72	4.45	110.14	CC002	0
2020CAL019	6.5	81	6.28	103.48	CC002	0
2020CAL020	7.1	84	6.99	101.62	CC002	0
2020CAL021	3.1	63	3.01	103.01	CC002	0
2020CAL022	4.1	71	4.27	96.01	CC002	0
2020CAL023	3.2	61	2.74	116.87	CC002	0
2020CAL024	5.3	75	5.01	105.71	CC002	0
2020CAL025	11.3	97	10.65	106.12	CC002	0
2020CAL026	11	96	10.33	106.49	CC002	0
2020CAL027	9.1	90	8.55	106.42	CC002	0
2020CAL028	4.6	73	4.63	99.30	CC002	0
2020CAL029	6.7	82	6.51	102.90	CC002	0
2020CAL030	3.6	66	3.45	104.39	CC002	0
2020CAL031	7.4	86	7.49	98.86	CC002	0
2020CAL032	5.7	73	4.63	123.05	CC002	0
2020CAL033	8.5	88	8.01	106.16	CC002	0
2020CAL034	6.2	76	5.21	118.95	CC001	0
2020CAL035	12.9	99	11.30	114.12	CC001	0
Guadalupe Creek						
2020GC001	17.5	118	18.90	92.59	GC006	0
2020GC002**	–	64	3.15	–	GC005	1
2020GC003**	–	56	2.13	–	GC005	0
2020GC004	10.5	97	10.65	98.61	GC005	0
2020GC005	8.1	83	6.75	120.07	GC005	1
2020GC006	5.8	82	6.51	89.08	GC005	1
2020GC007	4.1	68	3.76	108.94	GC005	0
2020GC008	59.7	184	69.40	86.02	GC005	0
2020GC009	4.1	71	4.27	96.01	GC004	0
2020GC010	6.4	78	5.62	113.80	GC004	0
2020GC011	3.9	67	3.60	108.22	GC004	0

FishID	Weight (g)	Fork-Length (mm)	W_s (g)	W_r (%)	Site	Black Spot Severity
2020GC012**	–	62	2.87	–	GC004	0
2020GC013	5.2	76	5.21	99.77	GC004	1
2020GC014	11.2	99	11.30	99.08	GC004	1
2020GC015	4.5	71	4.27	105.37	GC003	1
2020GCK016	28.4	145	34.55	82.19	GC001	1

* The standard weight equation used in the analysis applies to juvenile *O. mykiss* between 50-200 mm fork-length; therefore, individuals with fork-lengths >200 mm were excluded.

** Three individuals sampled from Guadalupe Creek were not weighed and relative weight could not be calculated.

Guadalupe River Watershed *Oncorhynchus mykiss* 2019 – 2020 Migration Monitoring Using Passive Integrated Transponder Tags



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Appendices

Appendix A: PIT Tag Master List

Appendix B: Pond A8 Notch and Guadalupe River PIT Antenna Operation 2019-2020 Monitoring

1. Introduction

The Guadalupe River Watershed begins in headwater tributaries near the summits of Loma Prieta and Mount Umunhum, draining the eastern Santa Cruz Mountains of Santa Clara County to the east, then north into the mainstem of the Guadalupe River that flows into South San Francisco Bay via Alviso Slough. Major tributaries in the Guadalupe River Watershed include Guadalupe Creek, Alamitos Creek, Los Gatos Creek, and Calero Creek. The federally threatened Central California Coast (CCC) steelhead (*Oncorhynchus mykiss*) distinct population segment (DPS) persists in these systems, and the Guadalupe River is designated critical habitat between its confluence with San Francisco Bay and West Hedding Street in San Jose (70 FR 52570, September 2005).

In the fall of 2018 and 2019, Valley Water conducted juvenile *O. mykiss* sampling in the Guadalupe River Watershed. A total of one hundred and twenty-five appropriately sized *O. mykiss* were collected and tagged with passive integrated transponder (PIT) tags in 2018 and eighty-two appropriately sized *O. mykiss* were tagged with PIT tags in 2019 to study their movement within the Guadalupe River Watershed (Valley Water 2019 and Valley Water 2020a).

A PIT tag is a small radio transponder that contains a specific code, which allows individual fish to be assigned a unique identification number. As mentioned in the name of these tags, they are passive and do not require a battery to produce a signal. Rather than the tag transmitting a signal, a radio-frequency identification (RFID) system sends a radio frequency into the environment. When a PIT tag is within range and detected by the tag reading system, the unique identification code is relayed to the system along with date and time information. There are two different types of PIT tags, half-duplex (HDX) and full-duplex (FDX). HDX tags were chosen for this study as they are better suited to handle environmental noise. HDX PIT tags are charged when in the vicinity of HDX readers, which are installed as a component of a PIT antenna, which generate short magnetic pulses that wirelessly charge a capacitator inside the HDX PIT tag. When the reader stops sending the charge field, the tag uses the stored power to send

the tag number back to the reader without the interference from the reader. One stationary tag reading system was deployed on Guadalupe River, Guadalupe Creek, and Alamitos Creek, allowing for movement of *O. mykiss* to be detected as fish passed over the antennas and potentially out-migrated to the ocean.

The goal of this study was to track *O. mykiss* movement and migration in the Guadalupe River Watershed, as well as to gain a better understanding of juvenile migratory timing and behavior. Additionally, this study will hopefully reveal the proportion of the tagged population showing migratory tendencies and from which sub-watershed.

2. Methods

2.1 Fish PIT Tagging

Juvenile *O. mykiss* monitoring was conducted in the Guadalupe River Watershed in 2018 and 2019 at 24 sampling stations, including Guadalupe River, Guadalupe Creek, Los Gatos Creek, Calero Creek, and Alamitos Creek (Figure 2). In 2018 and 2019 there were 6 sampling stations on Guadalupe River, 6 on Guadalupe Creek, 4 on Los Gatos Creek, 3 on Calero Creek, and 5 on Alamitos Creek. Multi-pass depletion backpack electrofishing was conducted in October and November of each year at each station to determine the presence of *O. mykiss* as well as the composition of other fish species in the Guadalupe River Watershed (Valley Water 2019 and Valley Water 2020a). *O. mykiss* with a fork-length of 65 mm or greater were tagged during each sampling event. *O. mykiss* with a fork-length greater than or equal to 65 mm but less than 150 mm received a 12 mm HDX PIT tag, while *O. mykiss* with a fork-length of 150 mm or greater received a 23 mm HDX PIT tag (Figure 1). All PIT tagging was conducted in accordance with the PIT Tag Marking Procedures Manual (CBFWA 1999) by staff trained in the procedure.

A total of 125 *O. mykiss* were tagged in the Guadalupe River Watershed in 2018: 58 on Alamitos Creek, 50 on Guadalupe Creek, and 17 on Calero Creek. A total of 82 *O. mykiss* were tagged in the Guadalupe River Watershed in 2019: 45 on Alamitos Creek, 29 on Guadalupe Creek, 7 on Calero Creek, and 1 on Guadalupe River. One hundred

and ninety-four of these fish were tagged with 12 mm tags and 13 of the fish were tagged with 23 mm tags. No *O. mykiss* were observed or tagged on Los Gatos Creek in 2018 or 2019. Tagging locations are displayed in Figure 2. PIT tag numbers and associated biological data for all fish tagged by Valley Water in Santa Clara County are included in Appendix A.

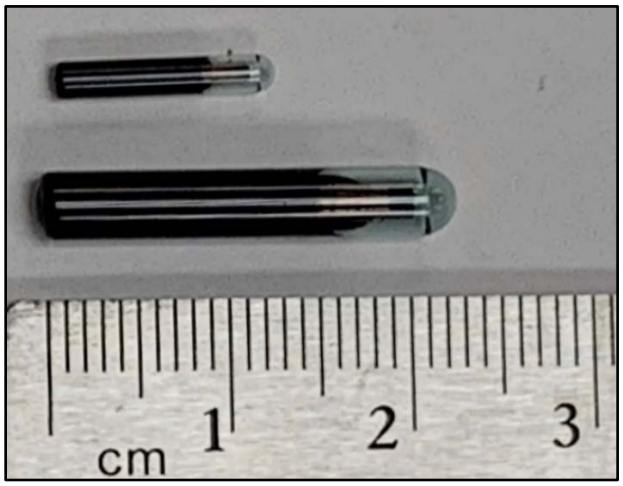


Figure 1. 12 mm (top) and 23 mm (bottom) HDX PIT tags.

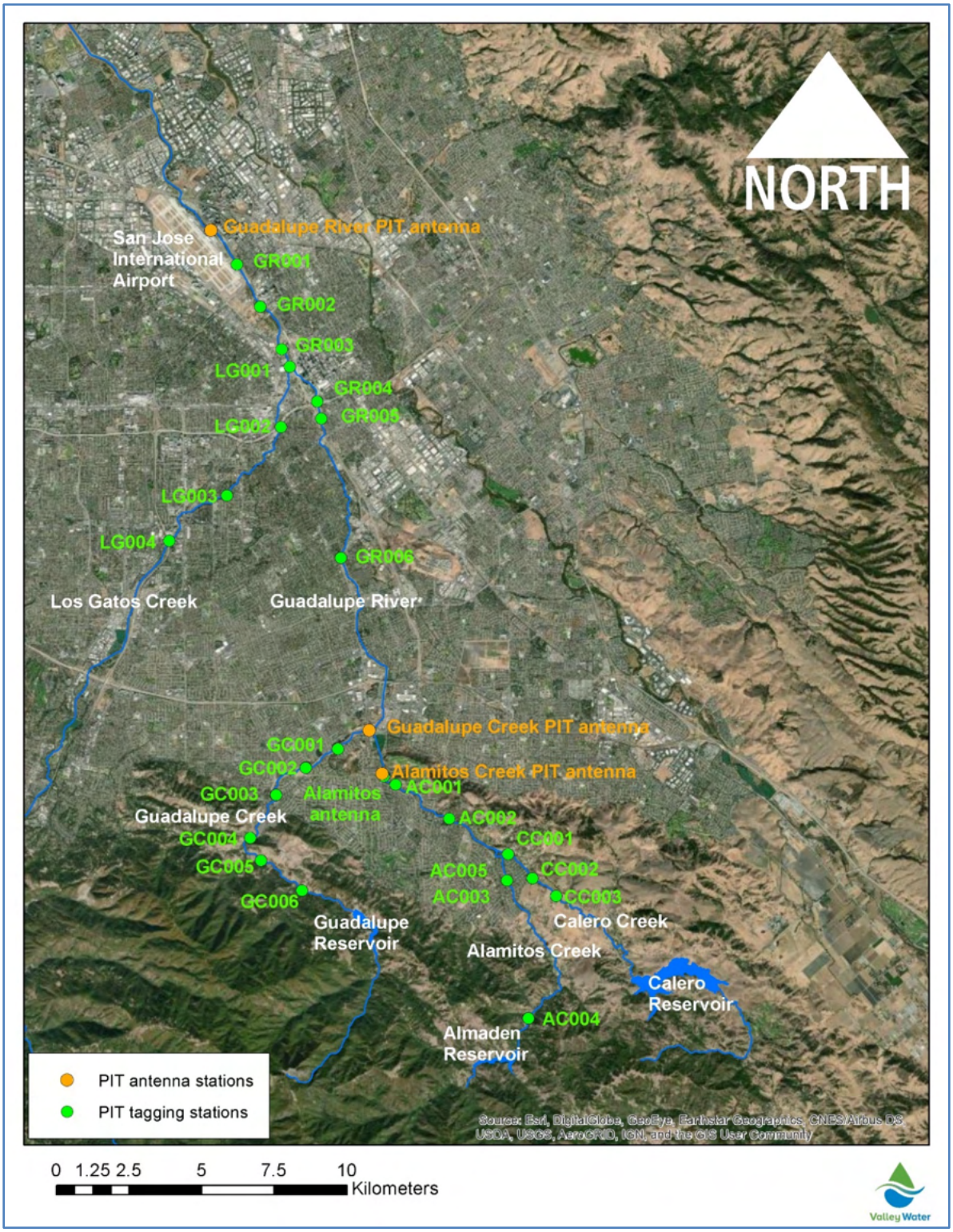


Figure 2. PIT tagging sampling stations from the 2018 and 2019 juvenile *O. mykiss* rearing study in the Guadalupe River Watershed. AC005 was not sampled in 2018 and Alamitos antenna was not sampled in 2019 (Due to the scale of this map, it is challenging to see this station behind the Alamitos Creek PIT antenna station).

2.2 Antenna Construction and Operation

Antennas installed in the Guadalupe River Watershed used HDX RFID technology. The basic components of the HDX arrays included an RFID reader, a power source, a tuning capacitor, and an antenna (http://www.oregonrfid.biz/). When readers detected a PIT tag, they stored the following detection data: PIT tag number, date and time stamp, number of times the tag was detected (14 scans per second), and number of scans since last detection. Detections recorded by the antenna indicated that a tagged individual was in proximity of the antenna at a given time but did not indicate direction of movement. Therefore, assumptions were made about direction based on the release point after tagging occurred and the position of the antenna in the watershed. Assumptions were also made that detections were of the target species and not tags that were either expelled and mobile in the system nor were in the digestive system of a predatory species.

One PIT antenna was installed on Alamitos Creek and Guadalupe Creek and two PIT antennas were installed on Guadalupe River. The Alamitos Creek and Guadalupe Creek antennas were installed and maintained by Valley Water; specifics of the antennas are described below. Details for the Guadalupe River PIT antennas are included in Appendix B as the installation, maintenance, and data analysis of these antennas was contracted out to FISHBIO.

Alamitos Creek Antenna

The Alamitos Creek antenna was installed on November 26, 2018, and thus the 2019-2020 monitoring period was the second *O. mykiss* migration season for which this antenna was deployed. This antenna is located downstream of the Calero Creek confluence, which provides the ability to detect potential outmigration that is occurring from both the Calero and Alamitos Creeks sub-watersheds. The antenna is approximately 10 m long by 0.4 m wide with a swim-over design and was fitted directly into a groove, cut specifically to hold the antenna, in a wood vortex weir (Figure 3). The weir was installed as part of the Valley Water Stream Maintenance Program (SMP) Alamitos Creek Instream Habitat Complexity Project that included large woody debris

implementation and gravel augmentation. The antenna consists of a single loop of 8 American wire gauge (AWG) copper wire passed through a plastic conduit that is imbedded in the groove of the weir. Plastic strappings and ceramic covered screws were used to secure the conduit in an attempt to reduce electrical noise and interference caused by metal near the antenna. The antenna is powered by a 120-volt wired receptacle and connected to a 12-volt power inverter.



Figure 3. Swim-over antenna at Alamitos Creek installed in a groove of the wood vortex weir.

The antenna provided complete lateral coverage of the channel during winter base flows, but during storm events some areas along the channel margin were not within a detectable range of the antenna. The average read ranges for PIT tags directly above the antenna were 17 cm for 12 mm PIT tags and 31 cm for 23 mm PIT tags. The average read ranges up- and downstream of the antenna were 3 cm and 15 cm for the 12 mm and the 23 mm tags, respectively. No antenna power outages or other failures occurred during the 2019-2020 *O. mykiss* migration monitoring season.

Estimates of the portion of the water column effectively scanned were made using physically measured PIT tag read ranges and outputs from the Hydrologic Engineering Center's River Analysis System (HEC-RAS), a computer program that models the hydraulics of water flow through a system, for hydraulic modeling in the Alamitos Creek sub-watershed. This data was reported in a figure in the Guadalupe River Watershed *Oncorhynchus mykiss* Migration Monitoring Using Passive Integrated Transponder Tags: Pilot Study report (Valley Water 2020b), however this year it was deemed inaccurate as the wood vortex weir is not geomorphologically similar to any of the transects measured along Alamitos Creek.

The antenna read range was field verified at 10.4 cfs at the Alamitos at Greystone (ALERT 5070) stream gage. The antenna provided complete coverage for both the 12 mm and 23 mm PIT tags well above the water depth of 12.5 cm directly above the antenna at the time of measurement. Given the 12 mm tag has an average read range of 17 cm above the antenna, the Alamitos antenna clearly provides complete coverage at flows higher than 10.4 cfs, but the upper limit of flow has not yet been determined through field verification. The daily average flow over the migration season only exceeded 10.4 cfs on 3 days meaning that for over 99% of the migration season the Alamitos antenna provided complete coverage. A depth to flow relationship is in the process of being developed by measuring the water depth directly above the antenna at a variety of flows.

Guadalupe Creek Antenna

The Guadalupe Creek antenna was installed upstream of the confluence with Guadalupe River on December 5, 2018. The 2019-2020 monitoring period was the second season of *O. mykiss* migration during which this antenna was deployed. This antenna is 10.3 m by 0.8 m with a swim-through design. The top of the antenna is supported with a static line and ratchet strap between two anchoring points, and the bottom is anchored into the channel substrate with round nail stakes (Figure 4). The antenna consists of a single loop of 10 AWG copper wire, which is connected to the static line and stakes with plastic zip-ties. Unlike the Alamitos Creek antenna, this wire

is not incased in a plastic conduit. The antenna is powered by a 120-volt wired receptacle connected to a 12-volt power inverter. Additionally, a marker tag, programmed to be detected every 30 minutes, was installed inside the detection zone of the antenna. This verified continuous antenna operation and demarcated the timing of outages after the antenna was damaged.



Figure 4. Swim-through antenna at Guadalupe Creek. Arrows point to the location, as the single loop of wire is difficult to see in the image.

The antenna provided complete lateral coverage of the channel during most flows, but during large storm events when the floodplain was inundated some areas along the channel margin were not detectable. The read range consistently spanned the entire height of the antenna between the top and bottom wires (0.8 m) for the 23 mm tags. The 12 mm tags had an average read range of 25 cm, which created a 30 cm dead zone in the middle of the antenna. The average read ranges up- and downstream of the antenna were typically 5 cm and 13 cm for the 12 mm and the 23 mm tags, respectively. The average read ranges above the antenna were 30 cm for the 23 mm tags and 18 cm for the 12 mm tags. Outages occurred as a result of high flows dismantling the antenna and disconnecting the electrical connections (Table 1).

Table 1. Guadalupe Creek antenna recorded outage type and duration during the 2019-2020 monitoring period.

Outage Type	Outage Start	Outage End
Reduced read range	12/31/2019 13:56*	1/15/2020 14:51
Complete	2/15/2020 14:50	2/19/2020 11:41
*Date and time of outage is often unknown as log files do not record all potential outage types.		

Estimates of the portion of the water column effectively scanned were made using physically measured PIT tag read ranges and outputs from the HEC-RAS hydraulic modeling in the Guadalupe Creek sub-watershed. The antenna was installed within a riffle, so the nearest cross section at a riffle crest was used as reference. Based on the modeling results, it is estimated that the Guadalupe Creek swim-through antenna provided complete coverage of the entire water column above the antenna up to 30 cfs as well as partial coverage (due to the dead zone) between 129 and 447 cfs for 12 mm tags. Additionally, the Guadalupe Creek antenna provided complete coverage at any modeled flow for 23 mm tags (Figure 5). These results do not account for inundation of the floodplain on either side of the antenna.

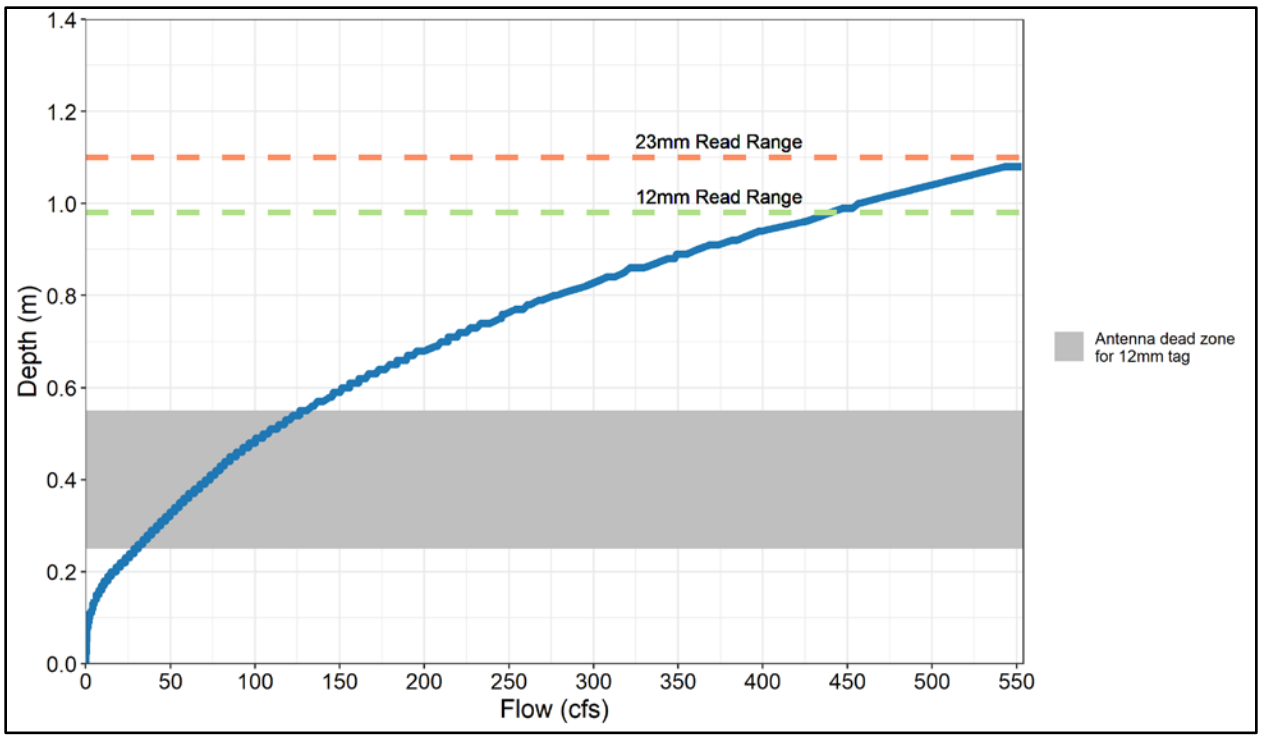


Figure 5. Modeled depth-to-flow cross sectional analysis overlaid with 12 mm and 23 mm tag average read ranges at the Guadalupe Creek antenna.

3. Results and Discussion

This monitoring report is for the 2019-2020 *O. mykiss* migration season. Therefore, the results presented below contain data collected from October 1, 2019 to May 31, 2020.

3.1 Alamitos Creek Antenna

O. mykiss were PIT tagged at five locations on Alamitos Creek and three locations on Calero Creek. A total of six individual tags implanted in *O. mykiss* were detected at the Alamitos Creek antenna during the 2019-2020 migration season (Table 2). Five of the tags were from *O. mykiss* tagged in the Alamitos Creek sub-watershed and one of the tags was from a fish tagged in the Calero Creek sub-watershed. Two of the tags detected were 23 mm tags and 4 of the tags were 12 mm tags. Relative paths of detected *O. mykiss* from their tagging locations to the Alamitos Creek antenna are shown in Figure 6. Fish movement did not appear to be limited by position in Calero Creek as a fish tagged at the most upstream station was detected at the Alamitos Creek

antenna. It cannot be determined if fish movement was limited by position in Alamitos Creek as there were no detections of fish tagged at the two most upstream stations on Alamitos Creek.

Prior to the start of the migration season, two *O. mykiss* from the Pescadero Creek Watershed (San Mateo County), tagged in the Pescadero Lagoon in a separate study by the California Department of Fish and Wildlife, were detected by the Alamitos Creek antenna in September 2019. One *O. mykiss* was 134 mm in fork-length, tagged on September 10, 2019, and tracked at the Alamitos antenna on September 17, 2019. The other *O. mykiss* was 128 mm in fork-length, tagged on August 13, 2019, and was detected at the Alamitos antenna on September 18, 2019. Since these detections were outside the monitoring season, they are not included in Table 2.

Table 2. *O. mykiss* tag number and associated information of each fish detected at the Alamitos Creek antenna during the 2019-2020 migration season.

Date Tagged	Date Last Detected	Tag ID	Creek	Tagging Station	Fork-length (mm)
9/17/2018	3/30/2020	900.226000319355	Alamitos Creek	Alamitos antenna	248
10/10/2019	4/27/2020	900.226000319265	Alamitos Creek	AC002	95
10/28/2019	4/25/2020	900.228000613713	Calero Creek	CC003	280
10/23/2019	4/8/2020	900.226000319273	Alamitos Creek	AC005	90
10/31/2019	3/25/2020	900.228000613718	Alamitos Creek	AC001	170
10/22/2018	12/1/2020	900.226000319390	Alamitos Creek	AC002	90

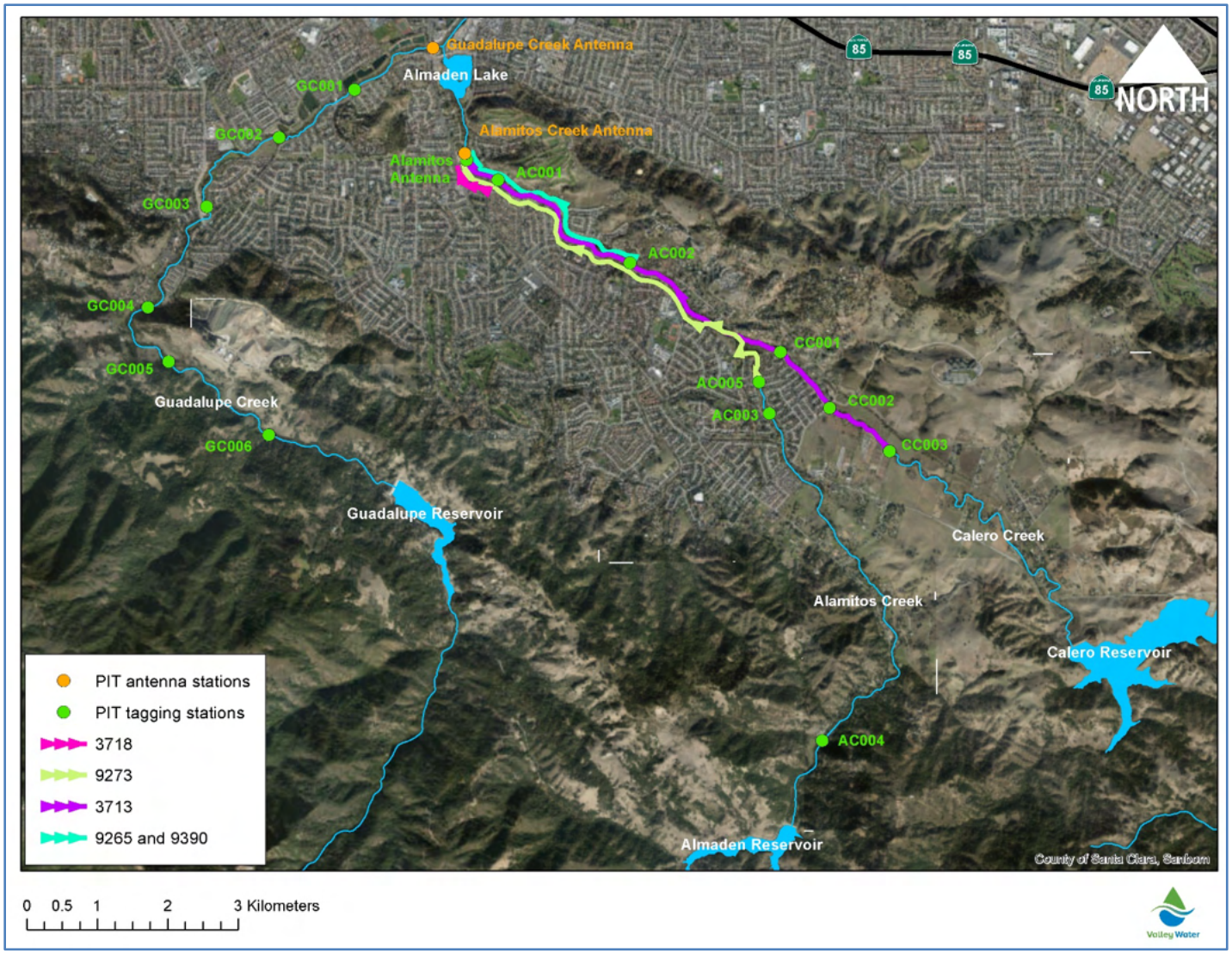


Figure 6. *O. mykiss* tagging locations and relative paths to the Alamitos Creek antenna. Numbers in legend indicate last four digits of *O. mykiss* PIT tag number. *O. mykiss* #9355 tagged at the Alamitos antenna station is not shown on the map as the PIT antenna and tagging location are the same location and directionality cannot be determined.

O. mykiss #9355 (last four digits of PIT tag identification number) was the only fish to be detected on multiple days during the migration season. The 248 mm fork-length fish tagged at the Alamitos antenna station was repeatedly detected and appeared to be utilizing the restored habitat from the SMP Alamitos Creek Instream Habitat Complexity Project. This fish was first tracked during the 2018-2019 migration season on November 26, 2018. This fish did not appear to have migratory tendencies. The other five *O. mykiss* were only detected on a single day during the migration season. However, #3713 was detected for a second time after the migration season on August 15, 2020. The four *O. mykiss* that were only detected once were likely out-migrating or showing other migratory tendencies.

As with all detections, it is uncertain if the tagged *O. mykiss* from Pescadero Lagoon were the live fish that were originally tagged or if predation occurred and they were brought into the watershed. At some point, both of the Pescadero Lagoon tags traveled the estimated 155 km trip from the Lagoon into the Alamitos Creek system. Both tags were only detected on a single day. There is also the potential that the tags were brought into the watershed by a bird but based on the detection rate (number of detections recorded per second) it seems more likely the detections were from passing fish (potentially a Chinook salmon (*Oncorhynchus tshawytscha*)) than a perching bird.

Movement of *O. mykiss* at the Alamitos Creek antenna was often associated with flow events (Figure 7). All detections occurred at flows under 10 cfs. Early season movement by fish #9390 in December appeared to occur around a small storm event, but it is not certain whether this movement was migratory or local movement. Since the antenna does not provide directional information, it is difficult to ascertain *O. mykiss* direction. Aside from movement associated with fish #9355 and #3713 that appeared to be resident *O. mykiss*, detections of the other four *O. mykiss* indicated migratory behavior as they occurred in March and April following the declining limb of the hydrograph. No detections occurred in January or February.

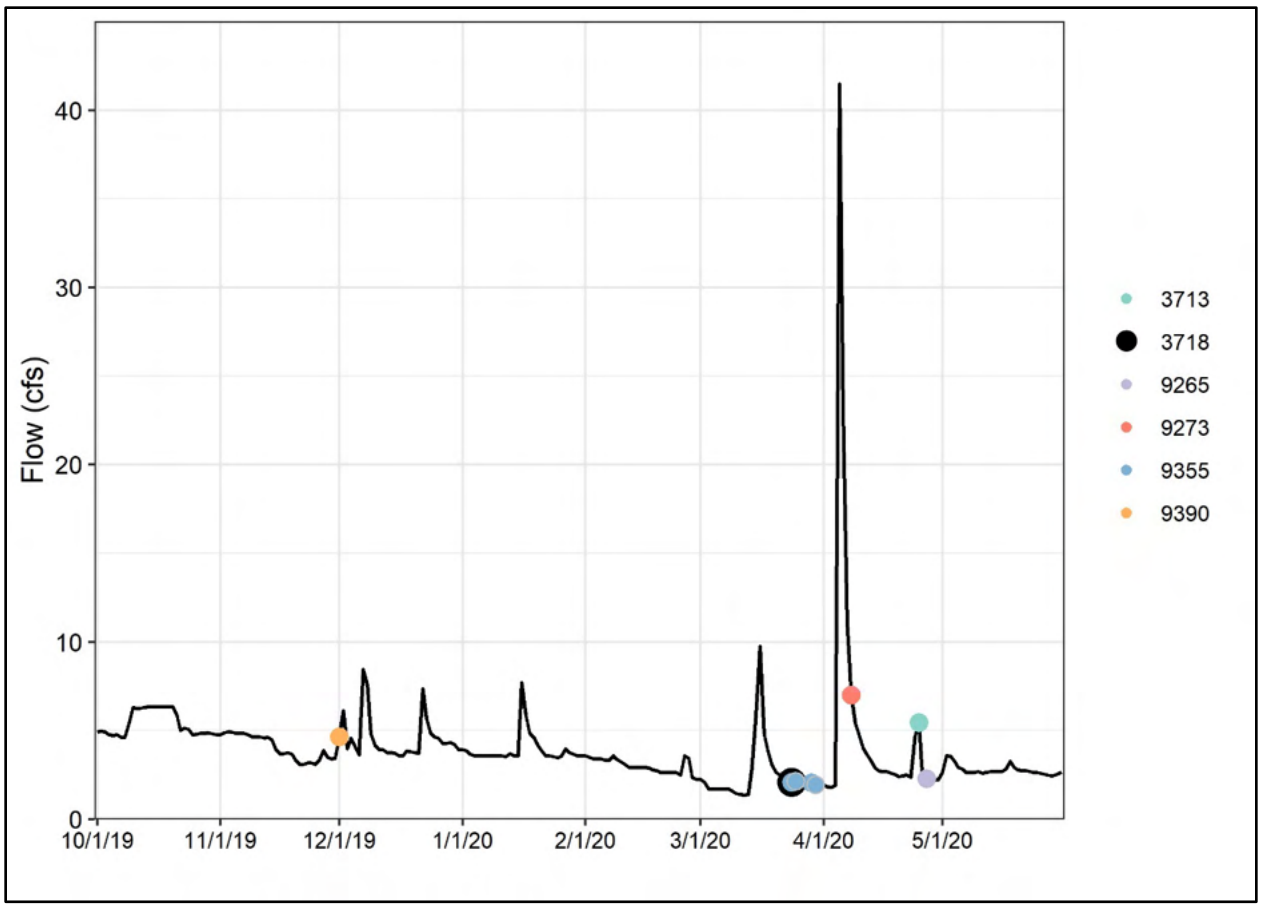


Figure 7. *O. mykiss* tracked by the Alamitos Creek antenna compared to average daily flow on Alamitos Creek at Greystone (ALERT 5070) Stream Gage.

The repeated detection of *O. mykiss* #9355 provides evidence of the success of the SMP Alamitos Creek Instream Habitat Complexity Project and shows that fish are utilizing the habitat within the first- and second-year post-construction in a wide range of flows.

The *O. mykiss* detected ranged from 90 to 280 mm in fork-length when tagged. These lengths were recorded 6 to 7 months prior to the detection date for fish tagged in 2019, and 14 to 19 months prior for fish tagged in 2018; thus, the detected fish were likely substantially larger in some instances than when they were initially tagged. The 248 mm *O. mykiss* (#9355) was the expected size of a resident *O. mykiss* and it displayed resident tendencies. The 280 mm fish (#3713) was also the expected size of a resident *O. mykiss* and while it was only detected once during the migration season, it was also

detected after the migration season on August 15, 2020, further indicating the likelihood of being a resident. The other four *O. mykiss* showing migratory tendencies tracked at the Alamitos Creek antenna were between 90 and 170 mm in fork-length when tagged. According to Moyle (2002), in small streams with low summer flows, like systems in the Guadalupe River Watershed, young-of-the-year steelhead measure 50–90 mm, and fish at the end of their second year measure 100–160 mm. Smith and Leicester (2016) aged 32 fish from Guadalupe Creek and found that young-of-the-year *O. mykiss* ranged from 85–114 mm, and fish in their second year ranged from 110–195 mm. This is a faster growth rate than predicted by Moyle (2002), but this is expected in warmer, more productive systems. Based on Moyle (2002) the *O. mykiss* detected by the Alamitos Creek antenna showing migratory tendencies were at the end of their first, second, and third years. Based on Smith and Leicester (2016) growth rates, *O. mykiss* detected by the Alamitos Creek antenna showing migratory tendencies were potentially at the end of their first and second years.

3.2 Guadalupe Creek Antenna

O. mykiss were tagged at six locations in Guadalupe Creek. The Guadalupe Creek antenna was located at the very downstream end of the system, before the confluence with the Guadalupe River. Areas downstream of the antenna are not consistent with habitat which would be conducive to rearing; therefore, the direction of movement of these fish should be easier to deduce because it is unlikely that these fish would be residing in the habitat downstream of the antenna. A total of eight individual tags implanted in *O. mykiss* were detected at the Guadalupe Creek antenna during the 2019-2020 migration season (Table 3). Seven of the tags were from fish tagged in the Guadalupe Creek sub-watershed and one of the tags was from a fish tagged on the Guadalupe River. The fish tagged in the Guadalupe River was tagged with a 23 mm tag and the 7 other tags detected were 12 mm tags. Relative paths of detected *O. mykiss* from their tagging locations to the Guadalupe Creek antenna are shown in Figures 8 and 9. Fish movement did not appear to be limited by position in the watershed as fish tagged at the most upstream station were detected at the Guadalupe Creek antenna.

Table 3. *O. mykiss* tag number and associated information of each fish detected at the Guadalupe Creek antenna during the 2019-2020 migration season.

Date Tagged	Date Last Detected	Tag ID	Creek	Tagging Station	Fork-length (mm)
10/9/2019	4/9/2020	900.226000319233	Guadalupe Creek	GC006	84
10/10/2019	4/6/2020	900.226000319296	Guadalupe Creek	GC003	82
10/30/2019	4/5/2020	900.228000613714	Guadalupe Creek	GR003	248
10/10/2019	4/5/2020	900.226000319242	Guadalupe Creek	GC003	91
10/9/2019	3/19/2020	900.226000319237	Guadalupe Creek	GC002	76
10/10/2019	3/17/2020	900.226000319272	Guadalupe Creek	GC001	107
10/10/2019	3/16/2020	900.226000319247	Guadalupe Creek	GC001	104
10/10/2019	3/15/2020	900.226000319288	Guadalupe Creek	GC004	82

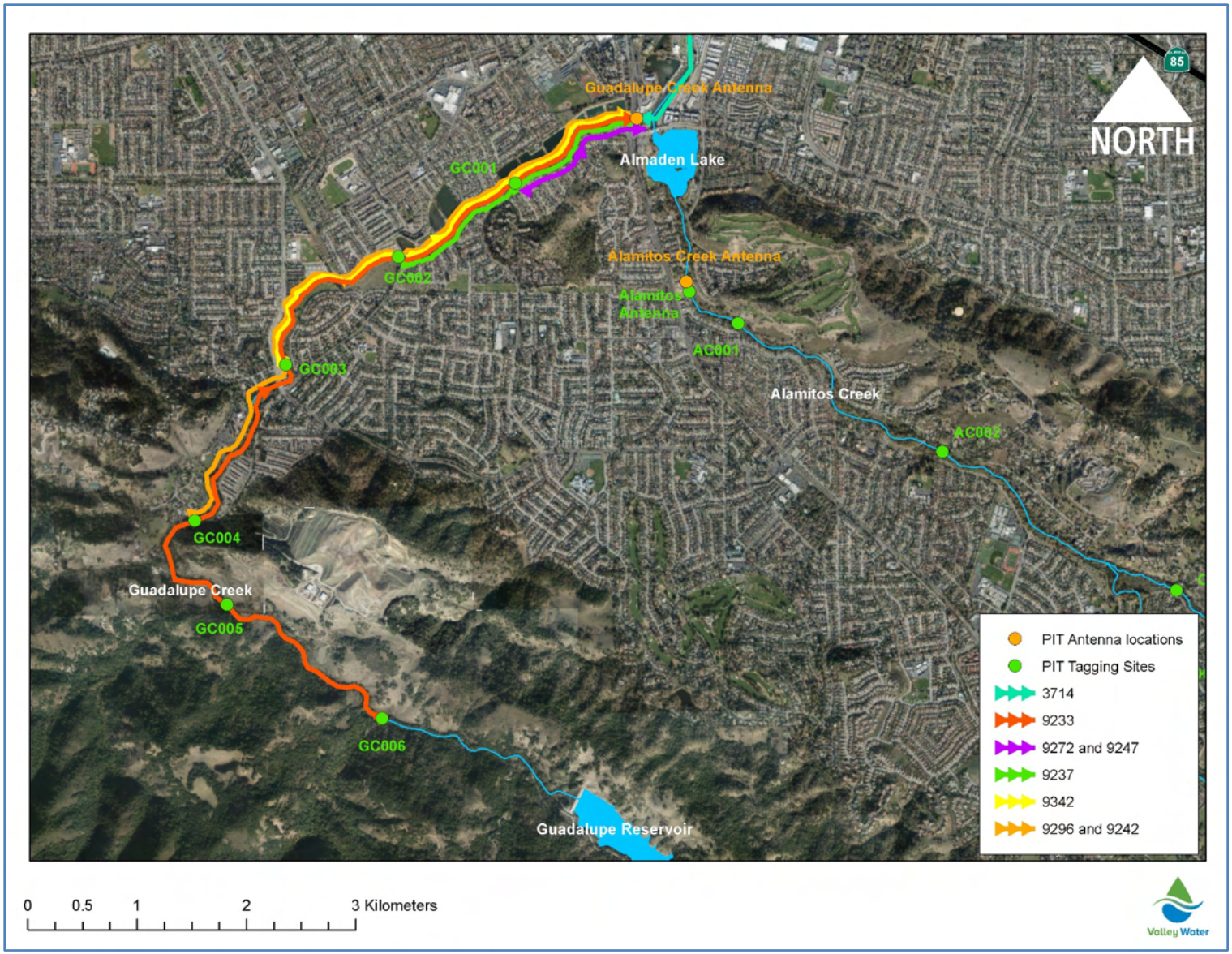


Figure 8. *O. mykiss* tagging locations in Guadalupe Creek and relative path to the Guadalupe Creek antenna.

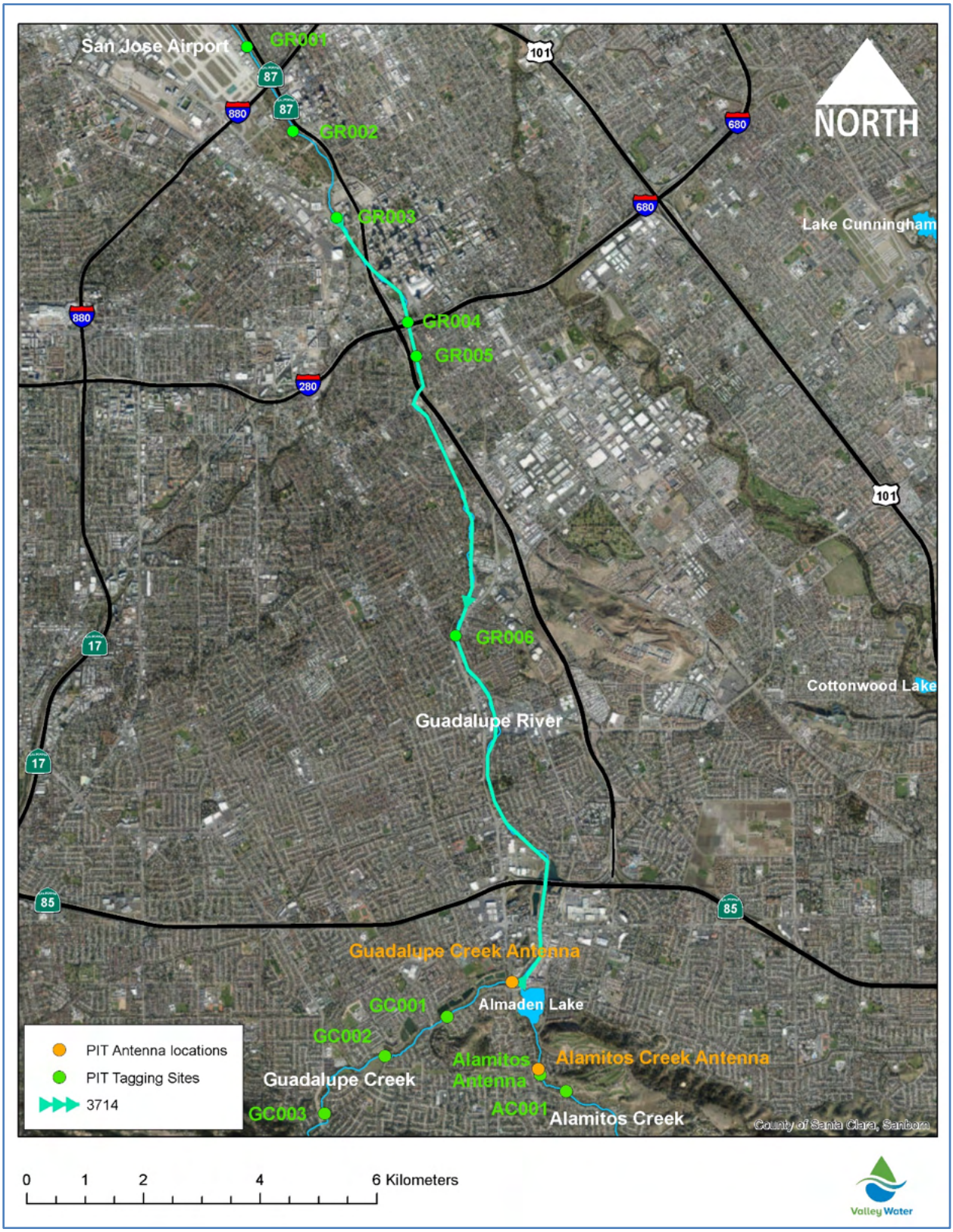


Figure 9. *O. mykiss* #3714 tagging location on Guadalupe River and relative path to the Guadalupe Creek antenna.

O. mykiss were not detected by the Guadalupe Creek antenna until March after the second large storm event of the season (Figure 10). Movement was associated with the declining limb, ascending limb, and peak of the hydrograph. All movement was detected when flows were less than 120 cfs and all detections occurred in March and April. Antenna read range was reduced for a period of up to two weeks in January, and it is possible that tagged fish were missed during this period. However, the antenna successfully detected the marker tag every thirty minutes throughout this period. It cannot be determined exactly when read range became reduced, but it occurred at some point between December 31, 2019 when read range was checked and performing well and January 14, 2020 when read range was checked and was performing at a reduced capacity. In order to be as conservative as possible, it was assumed that read range became impaired immediately after the last read range check on December 31, 2019. Additionally, there was a four-day complete outage in February, but since there were no storm events during the month of February, it is unlikely that any fish would have been moving during this period.

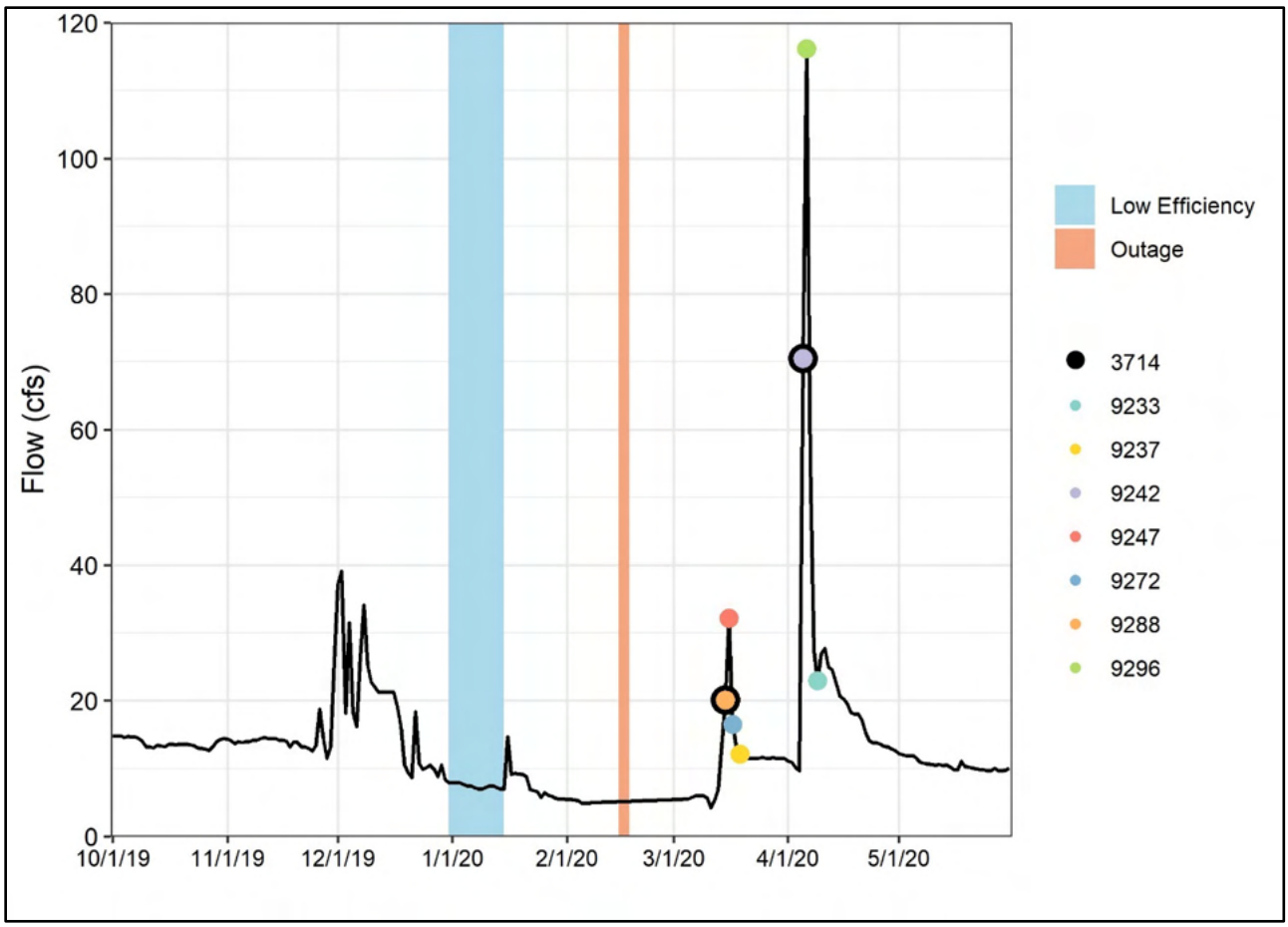


Figure 10. *O. mykiss* tracked on Guadalupe Creek compared to average daily flow on Guadalupe Creek at Hicks Road (ALERT 5043) Stream Gage and antenna outages. Numbers in legend indicate the last four digits of *O. mykiss* PIT tag numbers.

The *O. mykiss* detected in Guadalupe Creek ranged from 76 to 248 mm in fork-length when tagged. These lengths were recorded up to six months prior to the detection date, so the fish were likely larger than when tagged. The 248 mm *O. mykiss* (#3714) was the only fish detected on two occasions and that did not seem to be showing migratory tendencies. This fish was the expected size of a resident *O. mykiss*, but it was tagged on the mainstem of the Guadalupe River and showed smolt tendencies and attributes when tagged. This fish swam approximately 12.5 km upstream prior to being detected. The other seven detected *O. mykiss* showing migratory tendencies ranged between 76 and 107 mm in fork-length when tagged. Based on Moyle (2002), the seven *O. mykiss* detected by the Guadalupe Creek antenna showing migratory tendencies were at the end of their first and second year. Based on Smith and Leicester (2016) growth rates,

the seven *O. mykiss* detected by the Guadalupe Creek antenna showing migratory tendencies were at the end of their first year.

4. Conclusion

O. mykiss showing migratory tendencies were recorded from December through April, and *O. mykiss* from Guadalupe Creek and Alamitos Creek appear to be contributing to outmigration. The antenna arrays indicate that movement between sub-watersheds is occurring, and it also appears that *O. mykiss* might be entering the Guadalupe River Watershed from completely different watersheds; however, it cannot be confirmed if these fish were alive or in the gastrointestinal tract of a predatory fish or bird when the tag was detected by the array. Based on the size of *O. mykiss* detected, it is estimated that the *O. mykiss* showing migratory tendencies were at the end of their first, second, and third year. In a status review of West Coast steelhead, Busby et al. (1996) analyzed scale and otolith data from adult *O. mykiss* and found that the modal smolt age for *O. mykiss* in Washington, Oregon, and California was typically 2 years old. However, the most southern portion of the *O. mykiss* range had an increase in frequency of 1-year-old *O. mykiss* smolts compared with the northern portion. Based on this data, the *O. mykiss* tracked by the PIT arrays in the Guadalupe River Watershed appear to fall in line with what is typically expected of this population. The antenna also picked up non-migratory, resident *O. mykiss* behavior, which provided insight into the use of habitat restored through gravel and large wood augmentation by *O. mykiss*. Because this is only the second season of PIT tag monitoring in the Guadalupe River Watershed, results are rather limited, but a more robust dataset will develop as *O. mykiss* PIT tagging continues in the watershed over the coming years.

The value of adding additional antennas to help confirm directionality became clear this season, and directional antennas are planned to be implemented in the Guadalupe River Watershed for the upcoming 2020-2021 *O. mykiss* migration season.

5. References

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Moyle, B. P., et al. *Inland Fishes of California.* University of California Press, 2002.

Santa Clara Valley Water District (Valley Water). 2020a. 2019 Juvenile *Oncorhynchus mykiss* Rearing Monitoring in the Guadalupe River Watershed.

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Smith and Leicester (2016) Guadalupe Creek Fish Sampling in October 2015 and 2016. California Department of Fish and Wildlife and San Jose State University.

Appendix A
PIT Tag Master List

Tag Date	Creek	Weight (g)	Fork Length (mm)	PIT ID
9/17/2018	Alamitos Creek		199	900.226000319320
9/17/2018	Alamitos Creek	23.03	122	900.226000319348
9/17/2018	Alamitos Creek	13.3	102	900.226000319339
9/17/2018	Alamitos Creek	15.09	107	900.226000319313
9/17/2018	Alamitos Creek	8.33	89	900.226000319367
9/17/2018	Alamitos Creek		248	900.226000319355
9/17/2018	Alamitos Creek	12.92	103	900.226000319350
9/17/2018	Alamitos Creek	21.42	119	900.226000319366
9/17/2018	Alamitos Creek	19.34	117	900.226000319375
9/17/2018	Alamitos Creek	16.51	111	900.226000319326
9/17/2018	Alamitos Creek	23.78	122	900.226000319387
9/17/2018	Alamitos Creek	26.74	132	900.226000319376
9/17/2018	Alamitos Creek	30.42	141	900.226000319319
9/17/2018	Alamitos Creek	32.1	136	900.226000319352
9/17/2018	Alamitos Creek	13.3	103	900.226000319314
9/17/2018	Alamitos Creek	15.14	111	900.226000319353
9/17/2018	Alamitos Creek	11.5	97	900.226000319372
9/17/2018	Alamitos Creek	14.39	104	900.226000319316
9/17/2018	Alamitos Creek	14.48	106	900.226000319360
9/17/2018	Alamitos Creek	43.06	146	900.226000319370
9/17/2018	Alamitos Creek	32.7	138	900.226000319391
9/17/2018	Alamitos Creek	25.26	129	900.226000319310
9/17/2018	Alamitos Creek	81.27	186	900.226000319301
9/17/2018	Alamitos Creek	19.01	117	900.226000319384
9/17/2018	Alamitos Creek	11.97	102	900.226000319397
9/17/2018	Alamitos Creek	10	95	900.226000319388
9/17/2018	Alamitos Creek	18.58	115	900.226000319321
9/17/2018	Alamitos Creek	17.2	109	900.226000319322
10/16/2018	Guadalupe Creek	6.93	86	900.226000319364
10/16/2018	Guadalupe Creek	8.33	84	900.226000319358
10/16/2018	Guadalupe Creek	4.58	66	900.226000319338
10/16/2018	Guadalupe Creek	6.82	81	900.226000319385
10/16/2018	Guadalupe Creek	31.33	138	900.226000319389
10/16/2018	Guadalupe Creek	3.58	65	900.226000319308
10/16/2018	Guadalupe Creek	3.72	66	900.226000319334
10/16/2018	Guadalupe Creek	4.62	72	900.226000319305
10/16/2018	Guadalupe Creek	6.37	72	900.226000319341
10/16/2018	Guadalupe Creek	14.28	106	900.226000319293
10/16/2018	Guadalupe Creek	9.25	87	900.226000319276
10/16/2018	Guadalupe Creek	7.81	83	900.226000319227
10/16/2018	Guadalupe Creek	4.75	67	900.226000319318
10/16/2018	Guadalupe Creek	4.97	70	900.226000319351
10/16/2018	Guadalupe Creek	6.12	76	900.226000319329
10/16/2018	Guadalupe Creek	6.66	79	900.226000319345
10/16/2018	Guadalupe Creek	5.32	74	900.226000319324
10/17/2018	Guadalupe Creek	8.05	86	900.226000319344

10/17/2018	Guadalupe Creek	4.23	68	900.226000319330
10/17/2018	Guadalupe Creek	5.31	74	900.226000319398
10/17/2018	Guadalupe Creek	11.22	90	900.226000319304
10/17/2018	Guadalupe Creek	5.23	74	900.226000319362
10/17/2018	Guadalupe Creek	5.05	79	900.226000319327
10/17/2018	Guadalupe Creek	3.85	68	900.226000319393
10/17/2018	Guadalupe Creek	18.15	112	900.226000319328
10/17/2018	Guadalupe Creek	4.53	67	900.226000319354
10/17/2018	Guadalupe Creek	4.36	69	900.226000319379
10/17/2018	Guadalupe Creek	6.22	79	900.226000319374
10/17/2018	Guadalupe Creek	4.95	69	900.226000319356
10/17/2018	Guadalupe Creek	4.95	69	900.226000319325
10/17/2018	Guadalupe Creek	6.23	75	900.226000319395
10/17/2018	Guadalupe Creek	5.68	72	900.226000319371
10/17/2018	Guadalupe Creek	4.63	70	900.226000319377
10/17/2018	Guadalupe Creek	4.35	66	900.226000319399
10/17/2018	Guadalupe Creek	6.62	76	900.226000319342
10/17/2018	Guadalupe Creek	6.06	75	900.226000319307
10/17/2018	Guadalupe Creek	3.83	65	900.226000319333
10/17/2018	Guadalupe Creek	5.66	74	900.226000319361
10/17/2018	Guadalupe Creek	96.04	199	900.228000613702
10/17/2018	Guadalupe Creek	4.61	65	900.226000319381
10/17/2018	Guadalupe Creek	5.62	75	900.226000319346
10/17/2018	Guadalupe Creek	4.22	66	900.226000319394
10/17/2018	Guadalupe Creek	6.02	79	900.226000319386
10/17/2018	Guadalupe Creek	5.9	77	900.226000319340
10/17/2018	Guadalupe Creek	4.52	70	900.226000319317
10/17/2018	Guadalupe Creek	5.14	72	900.226000319337
10/17/2018	Guadalupe Creek	4.08	67	900.226000319309
10/18/2018	Alamitos Creek	3.25	65	900.226000319292
10/18/2018	Alamitos Creek	4.86	69	900.226000319295
10/18/2018	Alamitos Creek	20.6	125	900.226000319250
10/18/2018	Alamitos Creek	42.3	146	900.226000319257
10/18/2018	Alamitos Creek	16.8	110	900.226000319290
10/18/2018	Alamitos Creek	18.6	106	900.226000319269
10/18/2018	Alamitos Creek	4.23	66	900.226000319260
10/18/2018	Alamitos Creek	20.2	111	900.226000319200
10/18/2018	Alamitos Creek	17.5	109	900.226000319246
10/18/2018	Alamitos Creek	36.5	145	900.226000319258
10/18/2018	Alamitos Creek	14.8	79	900.226000319263
10/18/2018	Alamitos Creek	24.9	109	900.226000319201
10/18/2018	Alamitos Creek	12.5	94	900.226000319218
10/18/2018	Alamitos Creek	19	108	900.226000319311
10/18/2018	Alamitos Creek	5.35	68	900.226000319284
10/18/2018	Alamitos Creek	4.35	65	900.226000319291
10/22/2018	Alamitos Creek	10.2	90	900.226000319390
10/22/2018	Alamitos Creek	9.4	92	900.226000319363

10/22/2018	Alamitos Creek	445	345	900.228000613703
10/22/2018	Alamitos Creek	10	91	900.226000319365
10/22/2018	Alamitos Creek	12.8	103	900.226000319382
10/22/2018	Alamitos Creek	14.1	102	900.226000319315
10/22/2018	Alamitos Creek	9.6	91	900.226000319312
10/22/2018	Alamitos Creek	13	100	900.226000319349
10/22/2018	Alamitos Creek	13.8	98	900.226000319306
10/22/2018	Alamitos Creek	7.7	84	900.226000319343
10/22/2018	Alamitos Creek	28.2	129	900.226000319380
10/22/2018	Alamitos Creek	20.8	117	900.226000319368
10/22/2018	Alamitos Creek	23	119	900.226000319378
10/22/2018	Alamitos Creek	25.1	115	900.226000319396
10/23/2018	Calero Creek	125.2	216	900.228000613705
10/23/2018	Calero Creek	215.3	263	900.228000613704
10/23/2018	Calero Creek	7.3	82	900.226000319302
10/23/2018	Calero Creek	10.1	89	900.226000319332
10/23/2018	Calero Creek	5.2	67	900.226000319373
10/23/2018	Calero Creek	7.5	82	900.226000319280
10/23/2018	Calero Creek	14.3	109	900.226000319268
10/23/2018	Calero Creek	11.5	95	900.226000319336
10/24/2018	Calero Creek	9.3	84	900.226000319357
10/24/2018	Calero Creek	12.5	94	900.226000319244
10/24/2018	Calero Creek	8.5	85	900.226000319231
10/24/2018	Calero Creek	10.4	86	900.226000319300
10/24/2018	Calero Creek	5.4	75	900.226000319323
10/24/2018	Calero Creek	7.8	84	900.226000319347
10/24/2018	Calero Creek	10.2	93	900.226000319230
10/24/2018	Calero Creek	9.4	86	900.226000319212
10/24/2018	Calero Creek	8.3	82	900.226000319287
11/6/2018	Guadalupe Creek	18.2	116	900.226000319278
11/6/2018	Guadalupe Creek	12.4	95	900.226000319294
11/6/2018	Guadalupe Creek	8.7	87	900.226000319214
10/9/2019	Guadalupe Creek	8.6	84	900.226000319228
10/9/2019	Guadalupe Creek	14.7	104	900.226000319222
10/9/2019	Guadalupe Creek	5.1	71	900.226000319209
10/9/2019	Guadalupe Creek	53.6	168	900.228000613712
10/9/2019	Guadalupe Creek	9.6	85	900.226000319220
10/9/2019	Guadalupe Creek	8	76	900.226000319237
10/9/2019	Guadalupe Creek	152.1	234	900.228000613711
10/9/2019	Guadalupe Creek	7.1	81	900.226000319210
10/9/2019	Guadalupe Creek	9.5	88	900.226000319239
10/9/2019	Guadalupe Creek	6.6	84	900.226000319233
10/9/2019	Guadalupe Creek	5.73	75	900.228000613710
10/9/2019	Guadalupe Creek	5.8	77	900.226000319277
10/10/2019	Guadalupe Creek	13.4	104	900.226000319247
10/10/2019	Guadalupe Creek	16.5	107	900.226000319272
10/10/2019	Guadalupe Creek	10.4	91	900.226000319281

10/10/2019	Guadalupe Creek	9.5	89	900.226000319216
10/10/2019	Guadalupe Creek	7.7	81	900.226000319219
10/10/2019	Guadalupe Creek	10.2	91	900.226000319242
10/10/2019	Guadalupe Creek	7.1	81	900.226000319206
10/10/2019	Guadalupe Creek	14.3	99	900.226000319261
10/10/2019	Guadalupe Creek	6.5	82	900.226000319296
10/10/2019	Guadalupe Creek	16.3	106	900.226000319204
10/10/2019	Guadalupe Creek	41.7	150	900.226000319215
10/10/2019	Guadalupe Creek	7.9	85	900.226000319249
10/10/2019	Guadalupe Creek	3.4	66	900.226000319369
10/10/2019	Guadalupe Creek	9.4	89	900.226000319252
10/10/2019	Guadalupe Creek	8.6	86	900.226000319208
10/10/2019	Guadalupe Creek	8.6	82	900.226000319288
10/10/2019	Guadalupe Creek	12.3	100	900.226000319217
10/23/2019	Alamitos Creek	7.9	83	900.226000319254
10/23/2019	Alamitos Creek	15.1	106	900.226000319256
10/23/2019	Alamitos Creek	9	88	900.226000319211
10/23/2019	Alamitos Creek	11.4	95	900.226000319265
10/23/2019	Alamitos Creek	10.7	90	900.226000319273
10/23/2019	Alamitos Creek	22.9	122	900.226000319274
10/23/2019	Alamitos Creek	4.7	67	900.226000319240
10/23/2019	Alamitos Creek	14.4	105	900.226000319236
10/23/2019	Alamitos Creek	4.8	69	900.226000319223
10/23/2019	Alamitos Creek	11.5	87	900.226000319203
10/23/2019	Alamitos Creek	5.5	75	900.226000319205
10/23/2019	Alamitos Creek	3.3	65	900.226000319225
10/23/2019	Alamitos Creek	3.9	68	900.226000319282
10/23/2019	Alamitos Creek	4.9	71	900.226000319224
10/23/2019	Alamitos Creek	5.7	76	900.226000319248
10/23/2019	Alamitos Creek	13.9	105	900.226000319221
10/23/2019	Alamitos Creek	4.1	68	900.226000319202
10/23/2019	Alamitos Creek	5.3	72	900.226000319226
10/28/2019	Calero Creek	14.6	107	900.226000319286
10/28/2019	Calero Creek	250.1	280	900.228000613713
10/28/2019	Calero Creek	7.9	85	900.226000319259
10/28/2019	Calero Creek	12.3	95	900.226000319207
10/28/2019	Calero Creek	8.5	86	900.226000319245
10/28/2019	Calero Creek	12.4	96	900.226000319285
10/28/2019	Calero Creek	6.6	81	900.226000319297
10/30/2019	Guadalupe River	169.6	248	900.228000613714
10/31/2019	Alamitos Creek	8.5	90	900.226000319251
10/31/2019	Alamitos Creek	15.9	103	900.226000319262
10/31/2019	Alamitos Creek	15.1	105	982.126058146089
10/31/2019	Alamitos Creek	6.6	80	982.126058146053
10/31/2019	Alamitos Creek	281.8	280	900.228000613715
10/31/2019	Alamitos Creek	60.3	170	900.228000613718
10/31/2019	Alamitos Creek	40.1	150	900.228000613717

10/31/2019	Alamitos Creek	65.4	173	900.228000613716
10/31/2019	Alamitos Creek	7	81	900.226000319270
10/31/2019	Alamitos Creek	12.2	99	900.226000319232
10/31/2019	Alamitos Creek	28.8	134	900.226000319213
10/31/2019	Alamitos Creek	11.7	95	900.226000319241
10/31/2019	Alamitos Creek	5.8	75	900.226000319267
10/31/2019	Alamitos Creek	10.7	90	900.226000319298
10/31/2019	Alamitos Creek	6.3	76	900.226000319299
10/31/2019	Alamitos Creek	13.4	98	900.226000319234
10/31/2019	Alamitos Creek	11.6	93	900.226000319271
10/31/2019	Alamitos Creek	11.9	99	900.226000319255
10/31/2019	Alamitos Creek	11.5	95	900.226000319238
10/31/2019	Alamitos Creek	6.9	77	900.226000319283
10/31/2019	Alamitos Creek	25.4	130	900.226000319253
10/31/2019	Alamitos Creek	12	96	900.226000319229
10/31/2019	Alamitos Creek	14.1	97	900.226000319275
10/31/2019	Alamitos Creek	20.2	115	900.226000319279
10/31/2019	Alamitos Creek	33.6	140	982.126058146080
10/31/2019	Alamitos Creek	18.9	112	982.126058146069
10/31/2019	Alamitos Creek	19.5	117	982.126058146081
11/4/2019	Upper Penitencia Creek	96.5	209	900.228000613720
11/4/2019	Upper Penitencia Creek	171.5	245	900.228000613732
11/4/2019	Upper Penitencia Creek			900.228000613722
11/4/2019	Upper Penitencia Creek	7.8	85	982.126058146039
11/4/2019	Upper Penitencia Creek	11.3	93	982.126058146070
11/4/2019	Upper Penitencia Creek	63.9	177	900.228000613723
11/4/2019	Upper Penitencia Creek	59.4	178	900.228000613724
11/4/2019	Upper Penitencia Creek	8.5	84	982.126058146084
11/4/2019	Upper Penitencia Creek		79	982.126058146042
11/4/2019	Upper Penitencia Creek	24.1	130	982.126058146043
11/4/2019	Upper Penitencia Creek		106	982.126058146105
11/4/2019	Upper Penitencia Creek	12	92	982.126058146111
11/4/2019	Upper Penitencia Creek	7.6	84	982.126058146100
11/4/2019	Upper Penitencia Creek	17.3	108	982.126058146116
11/4/2019	Upper Penitencia Creek	48.2	162	900.228000613726
11/4/2019	Upper Penitencia Creek	10.8	92	982.126058146058
11/4/2019	Upper Penitencia Creek	41.1	158	900.228000613727
11/4/2019	Upper Penitencia Creek	5.2	73	982.126058146095
11/4/2019	Upper Penitencia Creek	7.2	85	982.126058146103
11/4/2019	Upper Penitencia Creek	15.5	103	982.126058146046
11/4/2019	Upper Penitencia Creek	10.7	100	982.126058146074
11/4/2019	Upper Penitencia Creek	5.8	78	982.126058146076
11/4/2019	Upper Penitencia Creek	41.9	156	900.228000613728
11/4/2019	Upper Penitencia Creek	38.6	145	982.126058146034
11/4/2019	Upper Penitencia Creek	49.2	162	900.228000613730
11/4/2019	Upper Penitencia Creek	12.5	101	982.126058146096
11/4/2019	Upper Penitencia Creek	6.2	78	982.126058146055

11/4/2019	Upper Penitencia Creek	13.3	96	982.126058146033
11/4/2019	Upper Penitencia Creek	8.7	88	982.126058146037
11/4/2019	Upper Penitencia Creek	6.9	83	982.126058146063
11/4/2019	Upper Penitencia Creek	13.1	102	982.126058146071
11/4/2019	Upper Penitencia Creek	143.1	234	900.228000613729
11/4/2019	Upper Penitencia Creek	5.8	75	982.126058146129
11/4/2019	Upper Penitencia Creek	55.3	172	900.228000613731
11/4/2019	Upper Penitencia Creek	11.5	98	982.126058146079
11/4/2019	Upper Penitencia Creek	19.2	112	982.126058146068
11/4/2019	Upper Penitencia Creek	6.2	79	982.126058146092
11/4/2019	Upper Penitencia Creek	7.9	86	982.126058146056
11/4/2019	Upper Penitencia Creek	5.2	74	982.126058146054
11/4/2019	Upper Penitencia Creek	6	76	982.126058146126
11/4/2019	Upper Penitencia Creek	17.8	111	982.126058146117
11/4/2019	Upper Penitencia Creek	15.1	108	982.126058146065
11/4/2019	Upper Penitencia Creek	9.9	94	982.126058146106
11/4/2019	Upper Penitencia Creek	9.1	88	982.126058146036
11/4/2019	Upper Penitencia Creek	19.7	112	982.126058146064
11/4/2019	Upper Penitencia Creek	7	79	982.126058146101
11/4/2019	Upper Penitencia Creek	9.3	89	982.126058146077
11/4/2019	Upper Penitencia Creek	75.1	189	900.228000613719
11/4/2019	Upper Penitencia Creek	12.4	97	982.126058146093
11/4/2019	Upper Penitencia Creek	5.1	74	982.126058146083
11/4/2019	Upper Penitencia Creek	13.8	105	982.126058146067
11/4/2019	Upper Penitencia Creek	4.5	73	982.126058146044
11/4/2019	Upper Penitencia Creek	8.7	91	982.126058146085
11/4/2019	Upper Penitencia Creek	5.3	77	982.126058146087
11/4/2019	Upper Penitencia Creek	6.3	81	982.126058146048
11/4/2019	Upper Penitencia Creek	8.7	90	982.126058146062
11/4/2019	Upper Penitencia Creek	6.3	78	982.126058146041
11/4/2019	Upper Penitencia Creek	13.9	101	982.126058146098
11/4/2019	Upper Penitencia Creek	5.5	77	982.126058146113
11/4/2019	Upper Penitencia Creek	5.1	74	982.126058146115
11/4/2019	Upper Penitencia Creek	8.6	90	982.126058146088
11/4/2019	Upper Penitencia Creek	151.3	236	900.228000613721
11/6/2019	Coyote Creek	18.1	112	982.126058146078
11/6/2019	Coyote Creek	28.2	133	982.126058146107
11/6/2019	Coyote Creek	23.2	122	982.126058146114
11/13/2019	Upper Penitencia Creek	54.7	168	900.228000613736
11/13/2019	Upper Penitencia Creek	35.2	149	982.126058146075
11/13/2019	Upper Penitencia Creek	147.8	238	900.228000613738
11/13/2019	Upper Penitencia Creek	46.3	159	900.228000613739
11/13/2019	Upper Penitencia Creek	23.5	124	982.126058146102
11/13/2019	Upper Penitencia Creek	68.9	184	900.228000613740
11/13/2019	Upper Penitencia Creek	119.5	224	900.228000613742
11/13/2019	Upper Penitencia Creek	7.5	84	982.126058146051
11/13/2019	Upper Penitencia Creek	7.5	86	982.126058146038

11/13/2019	Upper Penitencia Creek	30.5	140	982.126058146123
11/13/2019	Upper Penitencia Creek	9.8	88	982.126058146057
11/13/2019	Upper Penitencia Creek	12.2	97	982.126058146032
11/13/2019	Upper Penitencia Creek	8.7	80	982.126058146073
11/13/2019	Upper Penitencia Creek	23.6	125	982.126058146047
11/13/2019	Upper Penitencia Creek	15.7	94	982.126058146122
11/13/2019	Upper Penitencia Creek	13.8	94	982.126058146049
11/13/2019	Upper Penitencia Creek	9.1	86	982.126058146109
11/13/2019	Upper Penitencia Creek	8.8	84	982.126058146052
11/13/2019	Upper Penitencia Creek	24.5	124	982.126058146099
11/13/2019	Upper Penitencia Creek	26.3	128	982.126058146128
11/13/2019	Upper Penitencia Creek	73.5	184	900.228000613743
11/13/2019	Upper Penitencia Creek	38.5	134	982.126058146124
11/13/2019	Upper Penitencia Creek	2.9	84	982.126058146045
11/13/2019	Upper Penitencia Creek	110.3	209	900.228000613744
11/13/2019	Upper Penitencia Creek	28.9	132	982.126058146108
11/13/2019	Upper Penitencia Creek	12.4	96	982.126058146090
11/13/2019	Upper Penitencia Creek	37.2	154	982.126058146059
11/13/2019	Upper Penitencia Creek	96.5	204	900.228000613737
11/13/2019	Upper Penitencia Creek	31.8	141	982.126058146110
11/13/2019	Upper Penitencia Creek	10.6	95	982.126058146131
11/13/2019	Upper Penitencia Creek	38.8	153	900.228000613734
11/13/2019	Upper Penitencia Creek	24.8	128	982.126058146118
11/13/2019	Upper Penitencia Creek	20.4	125	982.126058146082
11/13/2019	Upper Penitencia Creek	58.2	172	900.228000613735
8/4/2020	Upper Penitencia Creek	38.2	147	982.126058146943
8/4/2020	Upper Penitencia Creek		144	982.126058146121
8/4/2020	Upper Penitencia Creek	25.4	129	982.126058146947
8/4/2020	Upper Penitencia Creek	22.2	121	982.126058146948
8/4/2020	Upper Penitencia Creek	39.3	152	900.228000613803
8/4/2020	Upper Penitencia Creek	59.1	178	900.228000613802
8/4/2020	Upper Penitencia Creek	124	237	900.228000613804
8/4/2020	Upper Penitencia Creek	31.5	142	982.126058146963
8/4/2020	Upper Penitencia Creek	36.1	151	900.228000613801
8/4/2020	Upper Penitencia Creek	79.4	196	900.228000613806
8/4/2020	Upper Penitencia Creek		104	982.126058146086
8/4/2020	Upper Penitencia Creek	26.4	130	982.126058146954
8/4/2020	Upper Penitencia Creek		123	982.126058146066
10/21/2020	Guadalupe Creek	3.9	67	982.126058146127
10/21/2020	Guadalupe Creek	6.4	78	982.126058146094
10/21/2020	Guadalupe Creek	4.1	71	982.126058146060
10/21/2020	Guadalupe Creek	59.7	184	900.228000613747
10/21/2020	Guadalupe Creek	5.8	82	982.126058146130
10/21/2020	Guadalupe Creek	8.1	83	982.126058146119
10/21/2020	Guadalupe Creek	10.5	97	982.126058146050
10/21/2020	Guadalupe Creek	17.5	118	982.126058146061
10/21/2020	Guadalupe Creek	11.2	99	982.126058146104

10/22/2020	Guadalupe Creek	4.5	71	982.126058146072
10/28/2020	Stevens Creek	21	122	982.126058146870
10/28/2020	Stevens Creek	15.1	105	982.126058146097
10/28/2020	Stevens Creek	24.2	125	982.126058146872
10/28/2020	Stevens Creek	34.5	146	982.126058146923
10/28/2020	Stevens Creek	4.4	68	982.126058146881
10/28/2020	Stevens Creek	15.6	103	982.126058146902
10/28/2020	Stevens Creek	48.5	162	900.228000613748
10/28/2020	Stevens Creek	4.8	70	982.126058146867
10/28/2020	Stevens Creek	3.8	69	982.126058146909
10/28/2020	Stevens Creek	4.3	69	982.126058146926
10/28/2020	Stevens Creek	4.5	69	982.126058146911
10/29/2020	Stevens Creek	4.6	66	982.126058146903
10/29/2020	Stevens Creek	4.8	69	982.126058146908
10/29/2020	Stevens Creek	3.9	68	982.126058146927
10/29/2020	Stevens Creek	4.1	68	982.126058146919
10/29/2020	Stevens Creek	3.3	67	982.126058146891
10/29/2020	Stevens Creek	5.1	71	982.126058146913
10/29/2020	Stevens Creek	6.1	75	982.126058146914
10/29/2020	Stevens Creek	4.4	71	982.126058146892
10/29/2020	Stevens Creek	4.5	69	982.126058146890
10/29/2020	Stevens Creek	4.4	69	982.126058146861
10/29/2020	Stevens Creek	6.6	78	982.126058146875
10/29/2020	Stevens Creek	6.2	78	982.126058146920
10/29/2020	Stevens Creek	13.1	100	982.126058146874
10/29/2020	Stevens Creek	4.3	65	982.126058146899
10/29/2020	Stevens Creek	34.6	141	982.126058146900
10/29/2020	Stevens Creek	4.2	72	982.126058146858
10/29/2020	Stevens Creek	8.6	82	982.126058146924
10/29/2020	Stevens Creek	9.5	88	982.126058146888
10/29/2020	Stevens Creek	4.9	74	982.126058146922
10/29/2020	Stevens Creek	4.9	71	982.126058146931
10/29/2020	Stevens Creek	4.2	70	982.126058146918
10/29/2020	Stevens Creek	4.4	67	982.126058146925
10/29/2020	Stevens Creek	4.8	70	982.126058146886
10/29/2020	Stevens Creek	4.4	71	982.126058146897
10/29/2020	Stevens Creek	5	71	982.126058146921
10/29/2020	Stevens Creek	3.7	69	982.126058146928
11/2/2020	Calero Creek	5.2	74	982.126058146917
11/2/2020	Calero Creek	7.4	86	982.126058146847
11/2/2020	Calero Creek	3.7	66	982.126058146876
11/2/2020	Calero Creek	3.8	68	982.126058146850
11/2/2020	Calero Creek	8.9	87	982.126058146869
11/2/2020	Calero Creek	5.1	70	982.126058146859
11/2/2020	Calero Creek	2.9	66	982.126058146894
11/2/2020	Calero Creek	5.8	81	982.126058146841
11/2/2020	Calero Creek	6.2	76	982.126058146889

11/2/2020	Calero Creek	12.9	99	982.126058146860
11/2/2020	Calero Creek	7.6	86	982.126058146849
11/2/2020	Calero Creek	4.9	72	982.126058146856
11/2/2020	Calero Creek	6.5	81	982.126058146845
11/2/2020	Calero Creek	7.1	84	982.126058146904
11/2/2020	Calero Creek	11.3	97	982.126058146834
11/2/2020	Calero Creek	4.6	73	982.126058146863
11/2/2020	Calero Creek	9.1	90	982.126058146901
11/2/2020	Calero Creek	11	96	982.126058146896
11/2/2020	Calero Creek	295.5	290	900.228000613749
11/2/2020	Calero Creek	3.6	66	982.126058146910
11/2/2020	Calero Creek	3.9	67	982.126058146871
11/2/2020	Calero Creek	5.3	75	982.126058146912
11/2/2020	Calero Creek	4.1	71	982.126058146893
11/2/2020	Calero Creek	6.7	82	982.126058146833
11/2/2020	Calero Creek	4.8	71	982.126058146906
11/2/2020	Calero Creek	4	70	982.126058146915
11/2/2020	Calero Creek	7.2	81	982.126058146930
11/2/2020	Calero Creek	8.5	88	982.126058146862
11/2/2020	Calero Creek	5.7	73	982.126058146884
11/2/2020	Calero Creek	5.5	79	982.126058146887
11/9/2020	Alamitos Creek	157.8	239	900.228000613750
11/9/2020	Alamitos Creek	26.1	133	982.126058146864
11/9/2020	Alamitos Creek	14.6	94	982.126058146879
11/9/2020	Alamitos Creek	16.5	103	982.126058146898
11/9/2020	Alamitos Creek	19.4	106	982.126058146873
11/9/2020	Alamitos Creek	16.2	111	982.126058146851
11/9/2020	Alamitos Creek	162.5	240	900.228000613752
11/9/2020	Alamitos Creek	80	192	900.228000613751
11/9/2020	Alamitos Creek	25.8	125	982.126058146929
11/9/2020	Alamitos Creek	27.8	138	982.126058146854
11/9/2020	Alamitos Creek	9.8	95	982.126058146857
11/10/2020	Alamitos Creek	19.7	123	982.126058146838
11/10/2020	Alamitos Creek	6.6	79	982.126058146832
11/10/2020	Alamitos Creek	15.4	117	982.126058146916
11/10/2020	Alamitos Creek	23.1	132	982.126058146852
11/10/2020	Alamitos Creek	25.9	136	982.126058146868
11/12/2020	Alamitos Creek	29.7	135	982.126058146853
11/12/2020	Alamitos Creek	23.7	129	982.126058146839
11/12/2020	Alamitos Creek	9.8	90	982.126058146843
11/12/2020	Alamitos Creek	20.1	113	982.126058146877
11/12/2020	Alamitos Creek	31.5	133	982.126058146836
11/12/2020	Alamitos Creek	18.4	110	982.126058146878
11/18/2020	Guadalupe Creek	28.4	145	982.126058146882

Appendix B

Pond A8 Notch and Guadalupe River PIT Antenna Operation 2019-2020 Monitoring

Pond A8 Notch and Guadalupe River PIT Antenna Operation

2019-2020 Monitoring



The Pond A8 Notch at Alviso Slough.

Submitted to:

California State Coastal Conservancy

Prepared by:

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Project Background and Objectives

FISHBIO was contracted by the California State Coastal Conservancy (SCC) and project partners to assist in fisheries monitoring in Alviso Slough and Guadalupe River in support of the South Bay Salt Pond Restoration Project (SBSPRP). The National Marine Fisheries Service (NMFS) Biological Opinion (2009) requires fish entrainment studies associated with the water management regime and reconfiguration of the former salt-production ponds as they are restored or enhanced.

The SBSPRP was initiated in 2003 with the acquisition of over 15,000 acres of former salt production ponds. The project goals are to restore and enhance a mix of wetland habitats, to provide wildlife-oriented public access and recreation, and to provide flood protection in the South Bay (Trulio et al. 2007). The Alviso Pond Complex consists of 25 ponds and encompasses 7,900 acres at the southern end of the Bay.

As part of the SBSPRP a 40-foot water control structure – referred to as "the Notch" – was constructed in 2010 to control the flow of water in and out of former salt evaporation Pond A8. The Pond A8 Notch structure consists of eight five-foot wide bays that can be closed or opened independently to allow varying amounts of tidal exchange between the A8 Ponds (Ponds A8, A8S, A5, and A7) and Alviso Slough. There are also smaller, culverted water control structures connecting Ponds A5 and A7 to Guadalupe Slough and Alviso slough, respectively. However, those structures have sustained significant erosion damage and are no longer operable. They now allow only passive exchange.

The NMFS Biological Opinion for Phase 2 of the SBSPRP calls for a continuation of efforts initiated in Phase 1 to track the movement of juvenile Central California Coast steelhead (*Oncorhynchus mykiss*) into and out of the A8 Ponds through the Notch at the mouth of the Guadalupe River in Alviso Slough (NMFS 2018). The Opinion stated that this effort would be conducted for up to five steelhead migration seasons over the next 12 years, with the objective of assessing the risk of entrainment and the fate of entrained juvenile steelhead at the muted tidal connection of the A8 Ponds with the Guadalupe River.

To this end, FISHBIO constructed, installed, and operated a custom array of eight passive integrated transponder (PIT) antennas at the Pond A8 Notch, as well as a single antenna in the Guadalupe River near Airport Parkway. The construction and operation of these PIT antennas was intended to detect the movement of *O. mykiss* that were tagged by Valley Water in the Guadalupe Watershed. Valley Water has monitored rearing of juvenile *O. mykiss* in the Guadalupe River and Guadalupe Creek via backpack electrofishing since 2004 as a component of the downtown Guadalupe River Project (Valley Water 2019). The monitoring was concluded in 2013, but Valley Water recommended the continuation and expansion of monitoring efforts to better understand *O. mykiss* numbers and distribution in the Guadalupe Watershed. In 2018, Valley Water expanded the juvenile rearing monitoring beyond the Guadalupe River Project area to include Los Gatos Creek, Alamitos Creek, and Calero Creek to further improve understanding of juvenile *O. mykiss* distribution and densities, collect genetic information, and implement an *O. mykiss* tracking study using PIT tags.

In October and November 2018, Valley Water PIT tagged 125 *O. mykiss* with 12mm and 23mm half-duplex PIT tags. No *O. mykiss* were tagged in the Guadalupe River, 58 *O. mykiss* were tagged in Alamitos Creek, 50 in Guadalupe Creek, and 17 in Calero Creek (Valley Water 2019). In the fall of 2019 (October 10-31, 2019) Valley Water tagged 70 *O. mykiss* in the Guadalupe River Watershed (Table 2): 45 on Alamitos Creek, 17 on Guadalupe Creek, seven on Calero Creek, and one on the Guadalupe River (Valley Water 2020).

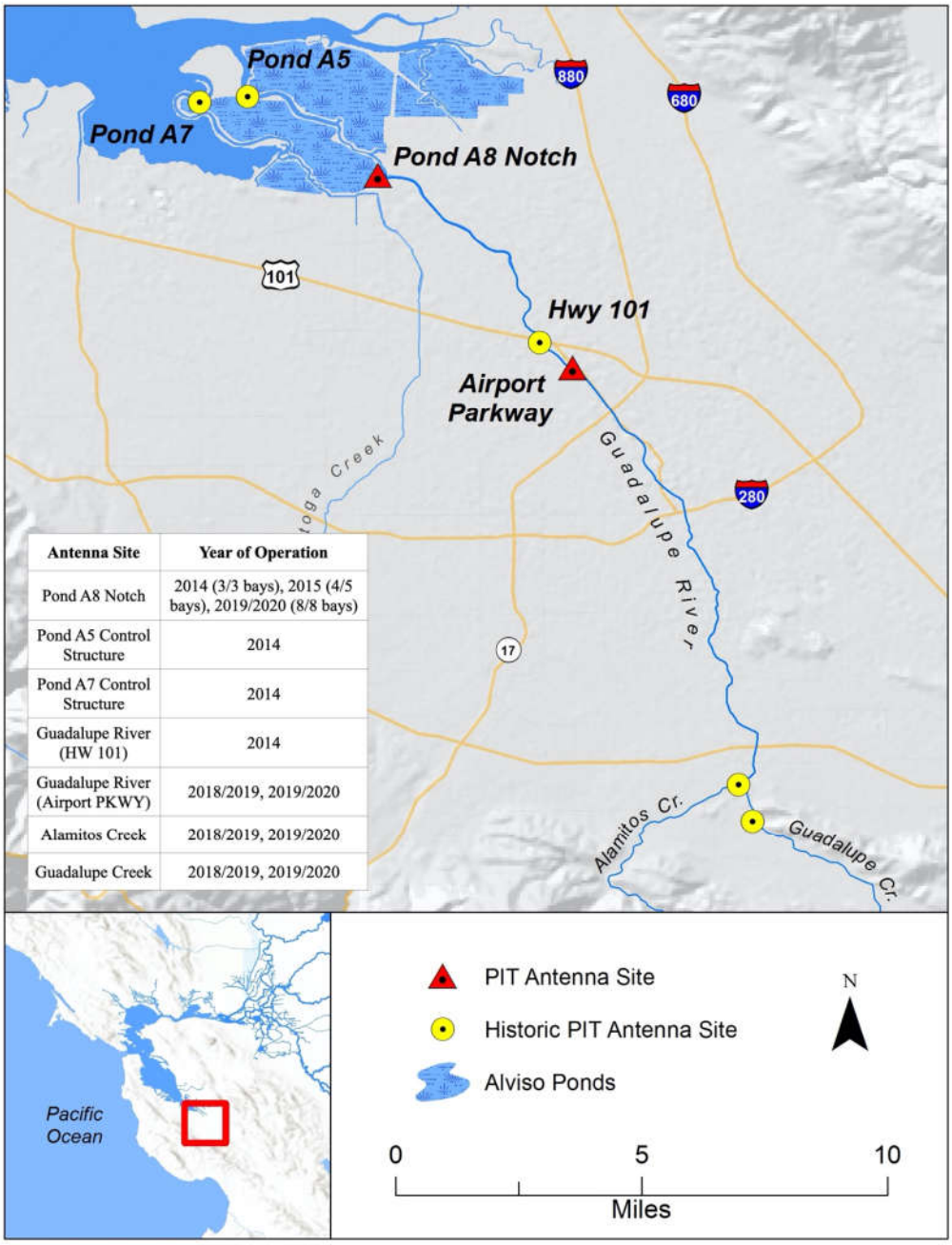


Figure 1. Map of PIT tag antenna stations in the South Bay Salt Ponds and Guadalupe River Watershed between 2014 and 2020. Sites operated for the 2019-2020 season are indicated by red triangles.

Methods

During planning stages with the SCC and Valley Water, it was determined that it would not be feasible to construct and install PIT tag antennas to monitor fish passage at the deteriorating Pond A5 and Pond A7 structures. Because any fish would have to enter Pond A8 through the Notch, it was decided that FISHBIO would construct new PIT tag antennas to monitor only the eight bays on the Notch utilizing existing PIT tag readers owned by Valley Water. It is highly unlikely that a lack of antennas at the A5 and A7 gates would preclude detection of fish exiting Pond A8, because those gates are relatively small openings at a distance of approximately two miles from the notch that would be hard for fish to find without attractive flows. A PIT tag antenna array was operated the Pond A8 Notch from November 9, 2019 through April 22, 2020 and an antenna was operated in the lower Guadalupe River from November 9, 2019 through March 25, 2020.

Multiple locations were considered for a lower Guadalupe River antenna and it was decided to replace an existing pass-over style antenna with a pass-through style antenna located at a concrete sack erosion control structure near Airport Parkway. The PIT tag antennas were intended to start monitoring October 1, 2019, but due to delays in receiving an encroachment permit from Valley Water the antennas at both locations were not installed until November. Construction of both the Pond A8 array and the Airport Parkway antenna was completed on November 9, 2019, at which time monitoring began. Timelines of monitoring at both locations are provided in the Results section.

The Pond A8 Notch PIT tag antennas were constructed from 2x6 inch lumber and measured 50 inches wide and 84 inches tall. These dimensions allowed them to fit snugly within the flashboard channels of each bay. Grooves were cut around the exterior perimeter of the wood antenna frame and 10 AWG stranded copper wire, a type often used for solar installations, was placed in the cut grooves to form two loops ½ inch apart. A layer of fiberglass and resin was applied over the surface of the antennas to provide additional strength and to protect the wire from abrasion or damage. Each antenna was equipped with an auto tuning board (Oregon RFID) mounted to the top of the antenna and secured within a watertight aluminum enclosure. The communication/power wire for each antenna was run from each bay into PVC conduit secured on the side of the Notch structure, and into the lockbox housing the readers and power supply. The Notch PIT tag antennas were constructed to last five years. Early model Oregon RFID single PIT readers were supplied by Valley Water, and all eight PIT tag readers were synchronized with one master reader controlling the timing of all readers in the array. Having all antennas within the array timed to send a charge pulse at the same time reduces the chance of antennas causing interference with one another.

The Airport Parkway antenna was a passthrough rectangle measuring approximately 24 feet wide by 30 inches tall. The antenna was constructed out of two loops of 10 AWG stranded copper wire with a ½-inch gap run through PVC conduit. The bottom of the antenna was a dome constructed out of fiberglass with two imbedded PVC pipes. This lower fiberglass portion of the antenna was attached to the concrete sack erosion control structure with concrete bolts. The top and sides of the antenna included two side by side ½-inch diameter PVC conduit with LB conduit bodies on the corners for access. The top of the antenna was supported first with ⅝-inch static line attached to anchor points on both sides of the river, but it was found to be incapable of maintaining the antenna

shape during high flow events. As such, it was replaced by ½ inch stainless steel cable. The antenna was intended to withstand flows up to 1,000 cfs and was designed to be easily rebuilt if damaged.

Up until the novel coronavirus (COVID-19) shelter-in-place order was issued in mid-March, the Airport Parkway and Pond A8 Notch antenna sites were checked at least once per week. As noted above, the Pond A8 Notch site consisted of multiple antennas, which were numbered 1 through 8 (Figure 2). This site was equipped with solar panels and an associated battery bank, and thus operated continuously without requiring battery changes. However, weekly site visits were made by FISHBIO personnel in order to download reader data, to assess the system for damage, and to retune antennas as necessary. Weekly visits were also made to Airport Parkway, where weekly replacement of the four six-volt batteries powering the system occurred in addition to data downloads and damage assessments. On occasions when damage to the antenna or other equipment was noted, additional site visits were made to conduct necessary repairs. For a detailed description of the occurrence of damage, repairs, and troubleshooting at both sites, see the Results section.



Figure 2. The number designations for the eight antennas at the Pond A8 Notch. This photograph was taken from the Alviso Slough side, looking towards Pond A8 on the far side of the structure. The substrate level varies considerably in each bay, as indicated by the disparity in height between antennas .

Results

Pond A8 Notch Antenna Array

Aside from a brief (three-day) interruption due to an issue with the solar controllers, across the entire monitoring period six of the antennas continually functioned properly (Antennas 1-6), one experienced only one additional two-day interruption (Antenna 8), and only a single antenna experienced an extended period of poor detection (Antenna 7). Despite logistical challenges, the reader data suggests that antenna coverage of the Pond A8 Notch was nearly complete for the duration of monitoring from installation on November 9, 2019 until the antennas vandalized on June 19, 2020 (Figure 3). During this period, only a single detection was recorded, and the origin of this single tag has not been determined (see Steelhead Detection section below). A description of the operational timeline and a record of antenna maintenance and repairs is provided below.

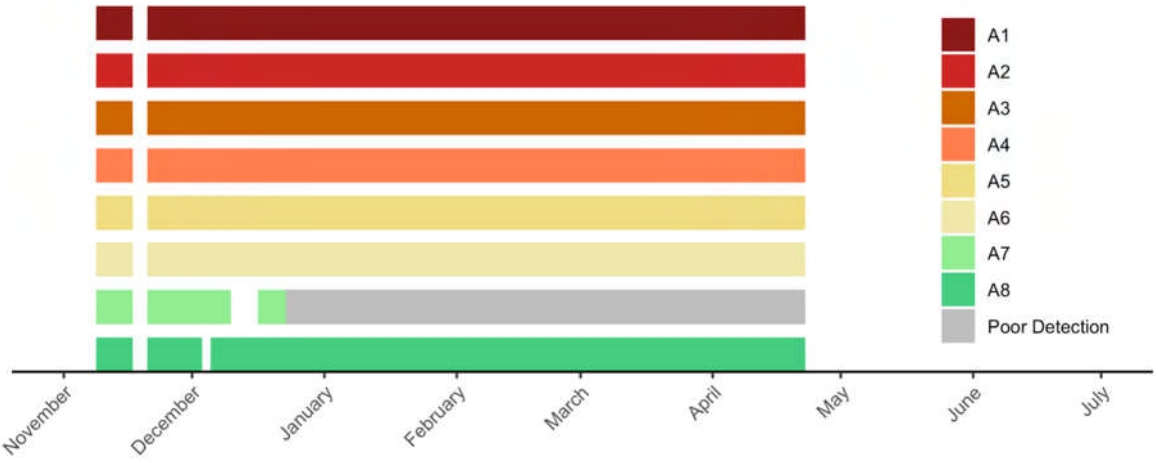


Figure 3. Operational timeline (November 9, 2019 through April 22, 2020) for all eight antennas at the Pond A8 Notch.

Monitoring began at the Pond A8 Notch upon completion of antenna installation on November 9, 2019. The following week, on November 15, it was noted during the weekly site visit that Antenna 7 was operating with low listening amps, and it was replaced with a new antenna during this site visit. Upon returning on November 19, it was noted that the solar controllers that had been installed were inadequate for the amount of power being generated by the two solar panels, which caused all eight antennas to shut down on November 17. New controllers were installed on November 20, and the array was once again monitoring normally with all eight antennas functioning. On a site visit on December 3, the PIT tag reader associated with Antenna 8 failed to reactivate after retuning. This faulty reader was replaced two days later on December 5. From this day through April 22, all antennas except Antenna 7 operated continuously through the remainder of the monitoring period.

On December 10, the PIT tag reader associated with Antenna 7 had a short on the power switch, causing it to deactivate. This reader was replaced six days later on December 16. On December 30 it was noted that Antenna 7 had low listening amps (~0.35, as compared to the >1.0 values of most of the other antennas), and use of a test tag indicated that there was a dead-zone in the middle of the antenna where tags were not being detected. Notably, Antenna 7 had physically dropped to a

level far lower than that of the other antennas, likely because the bay in which it was situated appeared to experience the highest volumes of flow during ebb and flood tides. Despite numerous attempts to retune, Antenna 7 continued to exhibit low listening amps and poor detection throughout the remainder of the monitoring period. On February 4, 2020 the download of the Antenna 7 reader indicated that no data had been recorded since the preceding download on January 30. It was reactivated but attempts to retune it to improve listening amps once again failed. On the next site visit on February 10, Antenna 7 was lifted out of the water for retuning, but this had no effect. However, use of a test tag on that same day indicated that all other antennas had good read ranges. On March 13, Antenna 7 was pulled out of the water and retuning was once again attempted. When this failed, continuity was tested to see if a break had occurred in the antenna, but the reading was normal. It was surmised that the tuning board was the cause of the poor read range, and Oregon RFID was contacted to obtain a new board.

It was at this time that the shelter-in-place order due to COVID-19 prevented further site visits, and FISHBIO personnel did not return to the Pond A8 Notch site until June 19. As such, there was no opportunity to replace the tuning board on Antenna 7, and it continued to operate with low detection through the remainder of the monitoring period. Upon returning to the site in June, it was discovered that all communication cables leading to the antennas had been severed, and a piece of concrete had been thrown onto one of the solar panels. Due to this damage, the antennas were no longer operational, but review of downloaded data indicated that they had continued to function until about 5 PM on April 22, at which time the cables were presumably cut. See Figure 3 for a visual timeline of the period of operation for each of the eight antennas.

Airport Parkway Antenna

Monitoring was initiated at the Airport Parkway site on the Guadalupe River when antenna construction was completed on November 9, 2019. A site visit on November 15 showed that the system had shut down on November 12 due to a loss of power. The batteries were replaced during the November 15 site visit, and to address the battery duration issue FISHBIO personnel began using four six-volt batteries instead of two starting on November 19. The addition of two more batteries appeared to be sufficient for the system to operate for at least a week at a time. The antenna was destroyed by high flows at 9 AM on November 26. It was rebuilt on December 6, but the high water level was found to have destroyed the tuning board. An attempt to replace the tuning board on December 7 failed, as the backup board was found to be faulty. A new tuning board was ordered, but when personnel returned to the site on December 10 to install it, they found that the antenna had been damaged again by high flows. The antenna was repaired, and the tuning board was replaced on December 12, but apparent interference prevented the system from tuning properly. Multiple attempts were made to address potential sources of interference. On December 14, FISHBIO personnel offset the steel top cable from the antenna and replaced the vertical pipe serving as a debris guard with a wooden post in order to prevent potential interference, but listening amps remained low. On December 20 it was found that someone had unearthed and attempted to burn the communication/power cable leading from the lockbox where the batteries were stored to the antenna. No break was detected, and the cable was reburied, but listening amps remained low due to continued interference. The strengthened antenna held up well to high flows in late December and did not break for the remainder of the monitoring period (Figure 4).

On December 23, personnel attempted to boost the system from 12 to 18 volts, but this had no impact on listening amps and the system was set back to 12 volts. Use of test tags on December 30 indicated that the antenna effectively detected 23mm tags but would not pick up a 12mm tag unless it was within four inches of the antenna. On January 7 the system was found to have lost power three days prior (on January 4) but operated normally when new batteries were attached. Attempts to use a test antenna near the recreational trail showed similar issues with poor tuning, suggesting that there was a generalized source of interference occurring in the area. Upon arriving at the site on January 21, the PIT tag reader was found to be non-responsive. It was replaced with a backup unit during this visit and the system was turned back on, but reactivating the original reader required a hard reset and firmware reinstall, which wiped the eight days of data it contained, so it is unclear when it ceased operating between the previous site visit on January 13 and the site visit on January 21 when it was found to be non-operational. On February 4, the reader was once again found to be non-responsive. Attempts to reboot it in the field failed, so it was brought back to the Santa Cruz office for a firmware reinstall. Once repaired, this single reader was reinstalled on February 7, and the system appeared to be functioning again, although listening amps were still quite low.

On February 10, the antenna was found to have much higher listening amps (>2). The source of interference appeared to have been eliminated and use of a test tag indicated it could effectively detect 12mm tags. The system continued operating normally, but on February 18 the reader was once again found to be non-responsive. This required a factory reset and firmware reinstall, which was performed onsite during this site visit. The system continued to function properly, and on March 10 a new firmware was installed in an attempt to address the recurring shutdown issue, which appears to have been due to a bug in the Oregon RFID software. This was the last site visit prior to the Santa Clara County shelter-in-place order issued on March 16. When personnel returned on June 19, the antenna was found to be intact despite high debris flows (Figure 4), but the reader had once again shut down and was non-responsive. The antenna, tuner, and reader were removed from the site at this time. Attempts to reactivate the reader failed, but the reader was sent back to Oregon RFID and data from March 10 through March 25 (when the batteries died) were recovered. A visual timeline of the period of operation for the Airport Parkway antenna is provided below (Figure 5).



Figure 4. Although significant debris had accumulated, the antenna was found to have remained intact upon removal on June 19.

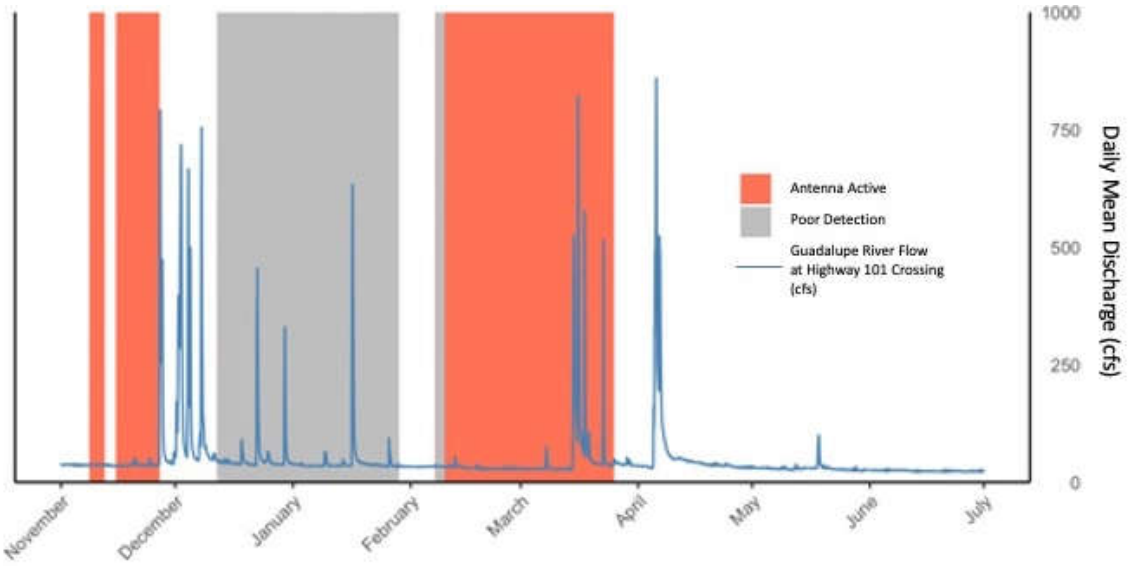


Figure 5. Operational timeline (November 9, 2019 through March 25, 2020) for the Airport Parkway antenna and Guadalupe River flow (in cfs) as measured by the USGS gauge at the Highway 101 crossing.

PIT Tag Detection

For the entire duration of monitoring at both Airport Parkway and the Pond A8 Notch, only a single PIT tag of an unknown species was recorded. This was tag 900_226000150002, which was detected at 3:30 AM on December 4, 2019 by Antenna 3 at the Pond A8 Notch site. This particular tag number was not included among those deployed by Valley Water. The tag number prefix indicates it was manufactured by Oregon RFID, therefore the number was submitted to Oregon RFID so that the project it was associated with could be informed. However, as of yet FISHBIO has received no information on the origin of this tag. Although the Pond A8 Notch antennas were in operation for most of the monitoring period, poor detection by the antenna in the bay that appeared to be experiencing the largest volume and highest velocity of flow (Antenna 7), and abrupt cessation of monitoring due to vandalism may have allowed tagged fish to pass by undetected. Further, review of reader data suggests that the detection ability (in terms of listening amps) of all eight antennas varied over the course of each day due to significant tidal flux (Figure 6), suggesting that certain tidal phases may have been associated with poorer detection range. To provide an example, Antenna 8 ranged from a low of 0.63 to a high of 1.16 listening amps on March 10, with periods of lower detection range aligning with ebb and low tide. The possibility of missed detections is even higher for the Airport Parkway antenna, which suffered from extensive periods of inoperation due to damage and poor detection due to unexplained interference. As Figure 5 indicates, the multiple periods of high flow in Guadalupe River fell almost entirely within periods of poor detection or inoperation of the Airport Parkway antenna.



Figure 6. High velocity flows during a flood tide at the Pond A8 Notch antenna site. Both water level and flow varied substantially with the tidal cycle.

Discussion

Previous Monitoring and Fish Tagging Efforts

The number of bays opened on the A8 Notch has gradually increased over the past nine years (Table 1) as environmental conditions and impacts on fish and wildlife have been monitored through various studies under the SBSPRP.

Table 1. Schedule of operation for the armored notch on Pond A8.

Open	Closed	Gates
6/1/2011	12/1/2011	1
6/1/2012	12/1/2012	3
6/1/2013	12/1/2013	3
3/4/2014	Not Closed	3
9/24/2014	Not Closed	5
6/2/2017	Not Closed	8

A two-year steelhead smolt outmigration and survival pilot study led by James Hobbs of the University of California Davis was conducted between 2013 and 2015. During the first year of the study, 70 juvenile *O. mykiss* were captured within the Guadalupe River Watershed, tagged with PIT tags, and released (Table 2). The study operated within a short timeframe. Tagging took place from December 16, 2013 to March 14, 2014. Of the 70 *O. mykiss* tagged that first year, six were detected at the remote RFID station just downstream of Highway 101 (Hobbs et al. 2014). The instream PIT tag antenna located in the Guadalupe River downstream of Highway 101, operated from February 12, 2014 to July 12, 2014. The PIT tag antenna array located around three open bays of the Pond A8 Notch structure operated from March 6, 2014 to July 12, 2015 and recorded one tagged *O. mykiss* that had also been detected by the Guadalupe River antenna at Highway 101. There were also PIT tag antennas installed around the Pond A5 and Pond A7 water control structures that operated from March 15, 2014 to July 12, 2014 but no tagged *O. mykiss* were detected at those locations. The six *O. mykiss* detected by the Guadalupe River antenna were all tagged within the Guadalupe River, with the most upstream location 6.5 km upstream of the antenna at St. John Street Bridge.

In year two of the study, PIT tag antennas on the Pond A5 and Pond A7 structures were not utilized, as they were destroyed by failing infrastructure (Hobbs 2015), and the Pond A8 Notch operated with five bays open. Only two of the three PIT tag antennas used at the A8 Notch from the first year were operable beginning February 15, 2015. An additional two PIT tag antennas were added on May 18, 2015, but one bay remained unmonitored for the duration of the second year of the study. During this second year the antenna in the Guadalupe River was destroyed by an early rain event and not replaced. In October and November of 2014 there were 28 *O. mykiss* tagged and

released in the Guadalupe River sub-basins (Table 2). Sixty-four of the 70 *O. mykiss* tagged in year one of the study were not recorded outmigrating that year, and therefore may have also still been in the system. However, there were not any *O. mykiss* detected at the Pond A8 Notch in 2015. In the spring of 2014 18 striped bass were captured, PIT tagged, and released at the Pond A8 Notch to assess predation risk. Three of the striped bass were detected – one multiple times a day on March 10 and again on March 20 – in 2015. The other two were only detected briefly and assumed to just be passing through.

During the winter and spring of 2018-2019, Valley Water operated three PIT tag antennas within the Guadalupe River Watershed. A swim-over antenna in Alamitos Creek below the Calero Creek confluence was installed on November 26, 2018; a swim-through antenna in Guadalupe Creek near the confluence with the Guadalupe River was installed December 5, 2018; and a swim-over antenna in the Guadalupe River was installed January 24, 2019. All three antennas experienced periods of inoperability for various reasons, and all three had decreased PIT tag detection efficiency with increased flows, as is common in most instream PIT tag antennas. According to a report of monitoring through May 31, 2019 (Valley Water 2020), six tagged *O. mykiss* were recorded by the Alamitos Creek antenna, six *O. mykiss* were recorded by the Guadalupe Creek antenna, and one *O. mykiss* was recorded by the Guadalupe River antenna.

At the Alamitos Creek antenna, three tagged *O. mykiss* were detected early in the monitoring period (December 2018 and January 2019), and all three had been tagged and released in close proximity (at Mazzone Drive and juvenile rearing monitoring site AC002, upstream of Graystone Lane) to the Alamitos Creek antenna. The other three *O. mykiss* were detected on March 21, March 24, and April 27, 2019 (Valley Water 2020). One of the six tags detected was an *O. mykiss* tagged in the Guadalupe Creek sub-basin and the other five tags originated in Alamitos Creek. The Guadalupe Creek antenna detected four tagged *O. mykiss* early in the monitoring period, between January 19 and February 2, 2019, and two other tagged *O. mykiss* were detected in March 2019. The one *O. mykiss* detection at the Guadalupe River antenna occurred on April 6, 2019, and that individual had been tagged in Alamitos Creek and not detected at any other PIT tag antenna locations.

Table 2. Total number of *O. mykiss* implanted with PIT tags in the Guadalupe Watershed.

Tagging Period	Total Tagged	Tagging Organization
Winter 2013- 2014	70	UC Davis
Fall 2014	28	UC Davis
Fall 2018	125	Valley Water
Fall 2019	70	Valley Water

Valley Water continued operating the PIT tag monitoring antennas at Alamitos Creek and Guadalupe Creek through the spring of 2020. The PIT tag antenna on the Guadalupe River was removed by Valley Water and replaced with an antenna by FISHBIO for monitoring covered by the scope of work within this project.

Unpublished data of monitoring at Alamitos Creek and Guadalupe Creek in 2020 was provided by Valley Water (Valley Water 2020). Between December 1, 2019 and April 27, 2020, six different

O. mykiss were detected at the Alamitos Creek antenna. Four of the *O. mykiss* were tagged in 2019 and two were tagged in 2018. Five were tagged in Alamitos Creek and one was tagged in Calero Creek. One of the *O. mykiss* (#9390) was tagged in 2018 in Alamitos Creek and was detected early this season on December 1, 2019, but detections of the five other *O. mykiss* occurred between March 25, 2020 and April 27, 2020.

The Guadalupe Creek antenna recorded eight different *O. mykiss* during 2020 monitoring (Valley Water 2020). All eight *O. mykiss* were tagged in 2019, seven of the *O. mykiss* were tagged in Guadalupe Creek and one was tagged in the Guadalupe River. The *O. mykiss* tagged in the Guadalupe River (fork length 248mm on October 30, 2010) was detected twice at the Guadalupe Creek antenna, first on March 15, 2020 possibly moving upstream, and again on April 5, 2020 possibly outmigrating. All six *O. mykiss* recorded at the Guadalupe Creek antenna occurred between March 15 and April 9, 2020.

Interestingly there were two out-of-basin tags recorded at the Alamitos Creek antenna, both of which were *O. mykiss* tagged in Pescadero Lagoon (San Mateo County). The first fish (#0929) was tagged August 15, 2018 and detected at Alamitos Creek on November 27 and November 28, 2018. The second fish (#1524) was tagged September 10, 2019 and detected a week later at Alamitos Creek on September 17, 2019.

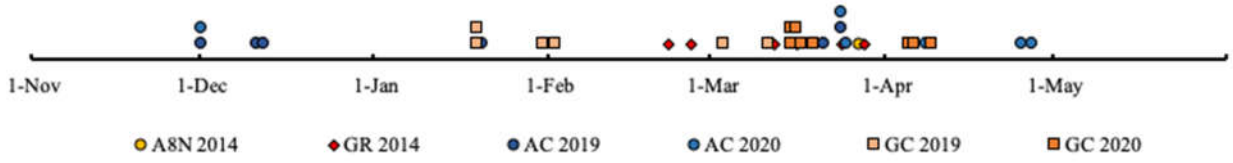


Figure 8. Date of tag first detection for all antenna sites all years: Pond A8 Notch 2014 (A8N 2014), Guadalupe River 2014 (GR 2014), Alamitos Creek 2019 (AC 2019), Alamitos Creek 2020 (AC 2020), Guadalupe Creek 2019 (GC 2019), and Guadalupe Creek 2020 (GC 2020).

It is difficult to predict the month in which tagged *O. mykiss* are most likely to be first detected with the limited existing dataset (Figure 8). The period of operation for each antenna and tagging locations have varied across years. Four *O. mykiss* have been detected in the months of December and January, and three in February. March is when the most *O. mykiss* detections have occurred (n = 16), with seven at Guadalupe Creek, four at both Alamitos Creek and the Guadalupe River, and one at the Pond A8 Notch. Repeat detections were not included in this analysis since they are more likely to be resident or rearing *O. mykiss* rather than outmigrating smolts. It is also important to note that the timing of outmigration may be highly dependent on the occurrence of storm events, which could result in distinctly different periods of peak movement across multiple years.

Challenges During 2019/2020 Monitoring

This project required substantial effort due to technical, logistical, and environmental challenges, and ultimately only a single detection of an unknown individual was recorded. However, it is worth

noting that the challenges encountered in trying to obtain data on passage into or out of the A8 Ponds through the A8 Notch as well as detecting movement further upstream in the Guadalupe River are not unique to the monitoring conducted by FISHBIO. The researchers performing past studies in the system (described above) experienced very similar difficulties in trying to obtain consistent and complete data on locations and movements of PIT-tagged fish. Considering these factors, the Pond A8 Notch PIT tag antenna array functioned remarkably well for such a challenging application. Operating eight antennas in close proximity surrounded by concrete, steel, and brackish water poses numerous confounding factors, and has likely not been attempted elsewhere. The PIT tag antennas fit into the existing flashboard notches securely, and FISHBIO personnel were able to install them from the bridge without entering the water. Further, the solar array and battery bank provided reliable power for all eight PIT tag readers for the duration of the monitoring period. Older model Oregon RFID PIT tag readers owned by Valley Water paired with newer model auto tuning boards functioned as expected. The auto tuning boards allowed for tuning to take place from the reader location instead of having to physically change jumpers on the tuning board located on the top of each antenna. There were some reader malfunctions that had to be contended with and these issues can be addressed should this project continue.

Recommendations and Lessons Learned

If these monitoring efforts are to be conducted in the future, a number of steps may be taken to help achieve better antenna functionality and to preclude several of the recurring challenges that have been noted in past studies. PIT tag reader technology is always improving and upgrading the equipment may confer a number of benefits. For example, it may be advisable to replace the older model single readers with the newest generation of Oregon RFID single readers, or with two modern Oregon RFID multiplex readers that have yet to be released to the public but may be available for use as part of beta testing efforts. The newest model Oregon RFID readers have GNSS satellite receivers to keep more accurate time and improve synchronization between readers. There are also optional cell modems to allow for remote status checks and data downloads. The most recent firmware for Oregon RFID PIT tag readers can be configured to periodically re-tune the antennas while running. This means that if environmental conditions change, like conductivity or water level during tidal flux, the the readers can be configured to re-tune the antennas at specified intervals and maintain maximum detection efficiency and read range.

Biomark is an alternative manufacture of PIT tag readers that are capable of dynamic antenna auto tuning and would continuously maintain read ranges in the changing environment at the Pond A8 Notch. The Biomark readers would provide additional benefits, including their BioLogic data retrieval and access service that provides access to multiple users and sends alerts if there is a problem. Biomark readers also detect both half duplex (HDX) and full duplex (FDX) tags, providing more options for using smaller PIT tags and detecting tags used by other researchers. The existing antennas would likely not be compatible with the Biomark readers and constructing new antennas would add to the cost of changing systems.

Having the ability to check on the status of the antenna array and conduct remote downloads would have been a valuable asset considering the circumstances of this monitoring season. With only weekly field site visits there can be periods of several days before becoming aware of a problem, leading to larger gaps in antenna coverage. The COVID-19 pandemic resulted in us not being able

to access the Pond A8 Notch site for over three months to check on the antenna status, conduct data downloads, and make improvements or repairs. As noted in the Results section, the communication cables that run from the PIT tag readers to the antennas were cut on April 22 but not discovered until June 19 when we were allowed to access the site. When the site was accessed on June 19 the data was downloaded but no repairs were made, nor equipment removed. One of the limitations with the older model Oregon RFID PIT tag readers is the potential for severe damage to the readers when powered without an antenna connected. Therefore, it is possible that all eight readers may not be operable for next season as a result of the vandalism that occurred. Once it is safe for FISHBIO to return to the site the readers will be removed and evaluated.

The Guadalupe River PIT tag antenna near Airport Parkway was much more of a challenge than anticipated, as detailed in the Results section. We believe we were able to strengthen the antenna to withstand flows of 1,000 cfs before being blown out, but there was a recurring problem with the new model Oregon RFID PIT tag reader used at the Guadalupe River site. When the reader shut down due to low power, as it is supposed to, it was resulting in freezing of the operating system. This necessitated reinstalling the firmware and sometimes losing saved data. We were working on this issue with the manufacturer through changing settings and installing updates to the firmware, but we are not confident this issue was resolved. A further issue was the radio interference that occurred between December 12 and February 10, which reduced the detection range of the antenna. It is not possible to determine the source of the interference, but it may have something to do with the proximity to the airport. Valley Water indicated that they had a similar issue at this location, so it may be a recurring problem and there is no guarantee that the same interference would not also occur at a new location. An alternative would be to install an additional antenna further away from the airport to provide some redundancy and improve our capabilities of determining *O. mykiss* outmigration and timing. To address inhibition of the Guadalupe River antenna at its current location due to radio interference, a mobile PIT tag antenna could be used to test alternative sites and determine the extent of the noise.

An additional sampling approach that may be warranted is the collection and analysis of environmental DNA (eDNA) samples. By collecting water samples from key locations in the watershed (e.g., Pond A8, Guadalupe River mainstem and tributaries), eDNA would allow for determination of where *O. mykiss* are in the system, and may also provide insight into when and where they are moving in response to changing environmental variables such as precipitation, flow, and water temperatures. During each weekly site visit to download PIT data, FISHBIO personnel could use our Smith-Root eDNA Backpack Sampler to filter water samples from various sites. The resulting data would identify the presence of *O. mykiss* in the area even if they do not possess PIT tags. Although this would not provide quantitative information, it would provide definitive data on *O. mykiss* presence/absence. If weekly samples were collected at the Pond A8 Notch and Airport Parkway sites from November through May, it would result in a total of 60 samples being collected. As such, there may be opportunity to expand eDNA sampling throughout the watershed by creating a strategically designed network of sample locations. The resulting data could be used to inform and improve the design of current monitoring systems. For example, frequent detection of *O. mykiss* DNA at locations not currently monitored by PIT antennas could indicate important coverage gaps, and conversely frequent detection of DNA at PIT antenna sites that are not associated with similarly frequent PIT tag detections could indicate that the antenna is

experiencing read range issues and/or that an insufficient proportion of the *O. mykiss* population is being tagged.

We recognize that all of the recommendations we provided will have additional costs associated with them. Estimates can be provided at the request of the study team and we will be happy to explore any ideas we may have overlooked.

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